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THE RECENT ECLIPSE IN EGYPT.*

ETHEL FOUNTAIN HUSSEY.

The unique interest that attaches to a total eclipse of the Sun is not hard to explain: it is beautiful, it is rare, it is tantalizingly brief, it is a clue to mysteries. That blazing star without which we should not know our own world, without which we should not know life at all, long stood behind its own light unrevealed. Now and then the Moon's disk, of just proportions to screen the unbearable brilliance, comes between, and there flash into sight the rose-red flames above the chromosphere, and that cold radiance never else suspected, the corona. A brief moment it hangs: then the following limb of the black disk crusts with red, a blinding spot of yellow appears, the light of common day again floods the sky, and the corona is lost like the dawn.

No other phenomenon has so stimulated solar research as this of total eclipse. Light had been analyzed in the laboratory, but the Sun's structure was first guessed here. Not alone the discoveries of the corona, the reversing layer, the chromosphere, and the prominences are to be credited to eclipse observations, but the initiative towards many of the successful methods of studying that body daily. Baffling was the brevity of the phenomenon until photography was applied to it, and although since that time the observable total eclipses of the Sun, clear and cloudy together, amount to barely half an hour, the results of that half hour, direct and indirect, are not paralleled by those of any equivalent period of time in scientific records. Yet every integral moment of it was beset with hazards outside the control of the investigators, no one of whom ever came home with his sheaf as large as he meant to gather.

All climes and all seasons have been invaded by the astronomer in his pursuit of the darkened Sun. The eclipse just past, August 30, 1905, is notable for an attempt, made through the generosity of Mr. William H. Crocker of San Francisco, to secure for the Lick Observatory photographic records from three points so widely separated as Egypt, Spain, and the Labrador. Cloud,

* The *Michigan Alumnus*, January, 1906.

the astronomer's enemy, brought to naught the Labrador endeavor, hindered in Spain, but left the Egyptian sky unvexed.

How the astronomers were welcomed who chose the country of the Nile to view the eclipse, how they were met and how they were cared for, is such a delightful retrospect to those who had the experience, that the temptation is great to tell that story rather than the sober one of the stress and heat and litter of the work-a-day camp. Each expedition was met at its port of entry by Captain Lyons, R. E., Chief of the Survey Department, vested with authority from the Egyptian Government to do all in his power for the aid and comfort of the visitors. With such generosity he interpreted that command, with such efficiency he carried it out that the ways of strange peoples, the mysteries of alien tongues, the business methods so contrary to our own, became as if they were not. Not only passes upon the railways, and franking of freight and luggage, but every detail of our journey, even ice and abundant fruit and drink for the last stretches of desert, were provided by the fore-thought of this watchful friend in a strange land. He came himself to Aswan and saw the earlier expeditions settled upon Elephantine Island where quarters had been engaged, long before their arrival, at the Hotel Savoy. Here two young Arabic-speaking engineers of the Department, Messrs. Keeling and Dickinson were detailed to duty so long as they should be of use, and with them four native overseers.

In the beautiful grounds of the Savoy our camps were soon established. Lumber and cement we found on hand, delivered by the Survey Department before we sighted the African coast. Did a new need arise? Achmed or Mursi was off in a felucca to the town. Did the bazaars of Aswan prove unequal to the occasion? There was the telegraph to Cairo, and the omnipotent Survey responded by the next up-train. Were we on the point of demoralizing the native by overabundant American cash, we were gently set right. The Egyptian supports a family on five piastres (twenty-five cents) a day: he blesses you for a prince at six; he holds you for a fool at ten.

Eclipse paths prefer the wildernesses. What a piece of fortune it seemed that this one, after leagues of Sahara, crossed the Nile at Aswan. This is the border town of Egypt, the most important post in many miles. Here Kitchener made his headquarters while he planned the opening of the Soudan. He razed the native huts along the river bank, and ran a boulevard around the crescent rim as wide as Ismail's road to the Pyramids. He dictated just where each new house should stand, the dimensions thereof, and the copious paint that should adorn the surface. He made

Aswan a shining city, and himself the best-hated man in the border-land. But there is no other view in Egypt like that from the point of Elephantine in the after-glow of a tropic sunset; white town and slender minaret burning like the sky, green palms quivering in the oven-like heat, great river placid as a lake after the turmoil of the cataract, the Hill of the Dome of the Winds, with its tombs and ruined monastery, standing silent guard.

Here in this rich neighborhood of beauty and eloquent history our strangely alien errand went on to its accomplishment. In all camps the routine is much the same. Rigid piers of brick and cement are the first necessity; after these the erection of polar axes, of fixed tubes, of clocks, of coelostats, or of plate carriages, according to the uses of the instruments. The disposition of fixed parts has all been predetermined by computation. The performance of each instrument in itself has been tested at home, nevertheless the finer adjustments have to be made on the spot, and with the greatest care. The Sun shifts his path each day, but lens and camera must be exactly in line for him at the all important moment of eclipse, with clocks accurately rated to follow his declining while the Moon's disk is passing his face. One instrument will compass the corona, another will catch the chromosphere, one wants but the instant after the Sun's disappearance, another waits for that last second before his return; one follows the apparition throughout totality, another turns quite aside from the Sun to his vicinity. No one of them, however, can wait till the eclipse has come and be aimed to it. It must be ready, with clocks so rated that there shall be no slips nor misconnections.

These last days of experimenting are, inevitably, absorbing ones, and blessed is the man who has not haste for his companion. In spite of precautions some alterations are certain to prove necessary. Two operations of note befell at Aswan, the first being to our own "Cross-eyed Lady." She was a combination of four telescopic cameras, long tubes of iron with a lens at each upper end, and a plate-holder of considerable size at the lower. Each lens pointed towards a different region in the Sun's neighborhood with the result that she seemed decidedly to squint, and so got her name. On the first day-time test there was evident some trouble with her vision. As she was looking for the lost planet Vulcan, this would never do. A consultation was held, and she was tried at night on the stars. The case was undoubted, pronounced brachymetropia beyond the exertions of the adjusting screw. Our neighbors came to see and shook their heads.

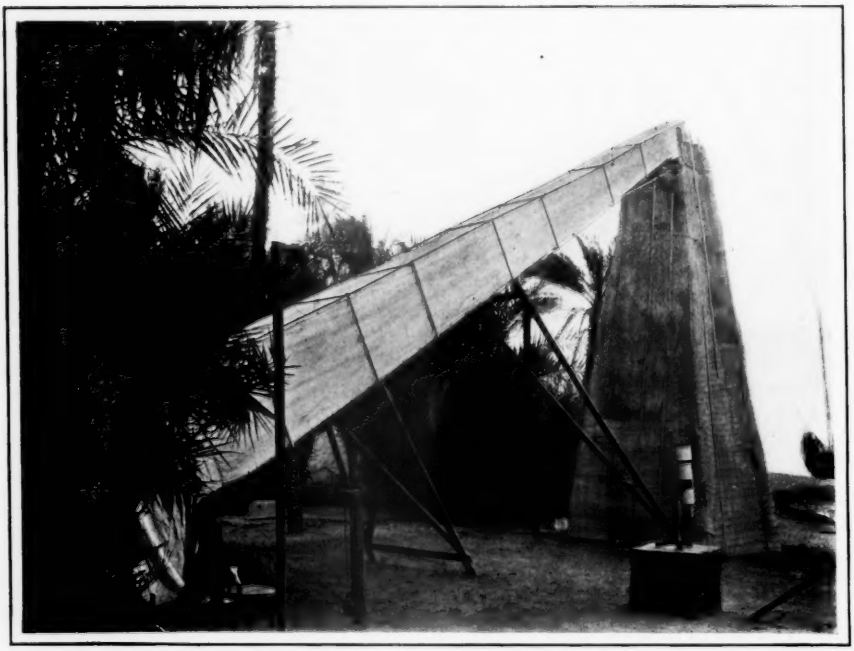
Were there mechanics in Aswan? Mursi and his felucca could not help us now. Cairo and the Survey Department were far and the eclipse was near. But the chief did not hesitate. With a hacksaw which he had learned to use on the Ohio farm, and with generous relief in the arm-racking labor from his colleagues, he operated upon the Cross-eyed Lady, rasping through sheet steel to the great interest of the assembled natives, who evince the same delight as the rest of us in seeing other people work.

More notable was the operation in the camp of Mr. Reynolds, who brought a very large reflector-camera from England, only to find when it was set up at this low latitude that the big mirror refused to throw so low a Sun as that at eclipse-time into its horizontal camera tube, but persistently hung it up in the top of a palm tree. I quote Professor Turner, who in his "Oxford Notes" chronicled our daily life at Elephantine. "Mr. Reynolds had considered it dangerous to allow a large 28-inch mirror to turn face downwards with only edge suspension, and the stops arranged to guard against this did their work a little too well. Various remedies were discussed. One was to chip a piece out of the cast-iron backbone of the coelostat; and this was actually done. The man who sat for a morning under a nearly vertical Sun chipping away cast-iron is proud to reckon the transaction among the notable achievements of his life. But it was not enough; more was needed, and the further question arose whether this should be exacted from the coelostat itself or from one of the piers. While bathing in the Nile after sunset we were interested to see that the maker of the telescope and the builder of the pier were discussing from which to take toll under somewhat novel conditions: they were seated on the soft bed of the river, their heads alone above the water, and were advancing in turn the claims of their respective theories with great earnestness. When all other bathers had left the river, the two heads were still there and still talking, and they made a striking picture in the growing darkness. It is pleasant to be able to record that the discussion ended harmoniously with a decision to alter *both* pier and telescope."

In the Egyptian summer one sleeps "*à* la belle étoile." From roof and balcony we wake on the morning of the thirtieth of August to a zenith of gold. But yesterday a gale has carried the fine dust of Sahara miles above and there each particle reflects the blazing Sun as he climbs from the depths of the heavens below the east. The wind has fallen to a faint breeze; not a cloud is seen, even on a far horizon.

Reproduced from The Independent of November 2d, 1905. Kearney, Photographer, Cairo.

Aswan Eclipse—The Great Camera-Reflector of Mr. Reynolds, Birmingham, England.



Reproduced from The Independent of November 2d, 1905. Photographed by W. J. Hussey.

The Forty-Foot Tube of the Lick Equipment, Elephantine Island.

The forenoon is given to rigorous inspection of the apparatus, several men examining each part of the equipment in turn and independently. For our enemies, heat, intense light and absolute dryness are silent and insidious. In this atmosphere wood cracks any hour. A washing-box filled with water warps into fissures that open to within a quarter of an inch of the liquid. The wet-bulb thermometer goes out of commission because the moisture cannot follow the wick. Wooden trays have been abandoned: wooden plate-holders split from end to end. Hence the utmost vigilance is exercised against mischief from this source, and extra bolts of black cloth are secured about the photographic apparatus in additional precaution against the intense light.

By afternoon the hotel has taken on some semblance of its winter gayety. Ministers and foreign attachés whom duty keeps in Cairo at all seasons have arrived by boat and train and a startling atmosphere of the Great World breezes through the halls. The bulletin board announces the time of first contact, totality, and the passing phases and there is much consulting of watches before it. The assistants who have come within the weeks are already at home in the camps, each ready for his simple but critical duties.

The Sun is declining, but not the day; the thermometer stands at a hundred and eight degrees. We think of Labrador and our colleagues on its misty shores. Would we could give them of our superfluities! We watch the hour pass and know that the shadow is sweeping across the chequered skies of "Sunny Spain." What luck, what luck to the long line of eager stations across the Peninsula? At 3:26:37 a spot like a sooty finger point first touches our unclouded Sun. The promptness of celestial schedules is disquieting. The acme of human effort is to be "on time to the minute;" on time to the second are the affairs of Moons and Suns. Strange too, to the onlooker is the fact that the Moon is absolutely invisible except such portion of it as encroaches upon the Sun. Out of nothing it comes: into the void it vanishes, and the eye strains in vain for a trace of it after.

During the hour of the encroaching Moon the stifling work of backing the photographic plates goes on in the dark-room, and when the Sun has dwindled to a thin crescent the assistants carry out the plate-holders wrapped none the less carefully in thick black cloth. Half of these go to the table in the dark tent, half to the instruments outside in the open. The operations in the tent are carried through by Mr. Hussey, with Mr. Dray of Cairo

assisting; those without are directed by Professor West, a Princeton graduate, long resident in Syria and Director of the Observatory of the Protestant College in Beirut. At the Spectrograph is Joy of Oberlin, and among those operating the Vulcan apparatus is Nelson of Chicago, both now of the Syrian College. Other Americans in the company are Mr. Godfrey of Zagazig in the Delta, and Mr. Bruce Giffen of Luxor. Our other helpers are from Cairo, Messrs. Swift and Wild from the Ministry of Public Instruction, Trimen and Curry from the Survey.

The green twilight settles in strange beauty over river and desert and palm grove, but, to the Camp, Egypt is forgotten. The last minute before totality has come. Each man is at his place. The sounder, beating seconds, cuts the silence sharply. The men in the dark tent watch the boiling rim of the Sun as it comes steadily up the plate carriage. A faint ghost of fire flashes out—The Corona!—though a blinding bead of light still hangs on the Moon's black edge. Ten seconds,—the red flames of the chromosphere burn into sight. Five seconds,—the shadow bands waver across the tent and shiver into the dusk—"Go!" snouts the signaller. Shutters flash and the steady count begins, "One—two—three—four—five." Even as the beat of the seconds the program goes through, without halt or omission, and the two minutes and a half are over for which we have been months preparing, and for which we have come our thousands of miles.

The evening banquet given by the Ministry of Finance in the Savoy grounds fitly crowned the series of official courtesies extended to the visiting expeditions, English, Russian and American. After the strenuous day the congratulation and good will came gratefully to those who had worked harder than they knew, and were more weary than they realized. What though there are hazards still to go through: so much is done, and well done. Sufficient unto the morrow are the evils thereof.

The gay guests go, the camps are demolished, our whilom companions depart and we are left alone to the trying work of developing and fixing the eclipse negatives at Aswan, that they may be sealed and shipped with as little risk as possible from the initial point of their long journey home. Our dark rooms are improvised, without conveniences or running water. Ice is brought daily from Cairo, five hundred and eighty miles. Its use is imperative in every bath, for the water temperatures are usually ninety degrees. The hotel filters are large and we have all their capacity at command, but the special solutions are made up with distilled water from Cairo. Not one is put upon an eclipse plate

until tested upon trial negatives. If these do not come up satisfactorily, patience must search the difficulty: how to meet the baffling conditions; to check one tendency, to increase another, to bring out detail, to seize the moment of balance between contending elements—study, thought, care, experiment, through nights of suspense and days of heat and little refreshment.

Ten large-scale photographs of the corona, and eight along the ecliptic in the Sun's vicinity are developed, besides these, a spectrograph which followed the entire period of totality. No detailed study of plates is made at an eclipse camp. This needs the resources of measuring engines, microscopes, comparison plates, and other records. At the observing station the one object is to bring out on each plate all the detail it will yield and fix it there against chance of accident from light or chemical change. The negatives are packed in their original boxes with edges separated by prepared paper strips. These are then compactly sealed in tin, and put in a strong wooden box, excelsior lined. This is then packed in one stronger still, securely fastened, aud labelled, in this case in three languages, French, English and Arabic. Our last news of it was from Mount Hamilton, that it had arrived, apparently in good condition, and was being unpacked under the eye of a United States Customs official, compliant to the laws of our Commonwealth.

ON THE METHODS EMPLOYED IN ANNOUNCING SATELLITE DISCOVERIES.

W. W. CAMPBELL AND C. D. PERRINE.

For Popular Astronomy.

On page 7, volume XVI, Journal of the British Astronomical Association, Mr. A. C. D. Crommelin, President of the British Astronomical Association, in his annual presidential address* before the Association, criticises the methods employed in announcing the discoveries of the three new satellites of 1905.

Mr. Crommelin's complaints began very shortly after the discovery of Jupiter's Sixth Satellite was announced. Although these complaints were, in our opinion, entirely unwarranted, yet they were presented more or less informally, and there was no necessity for replying to them. When statements which can scarcely fail to be misleading are made in a formal presidential address before an established society, the case is different.

* Reprinted in *Popular Astronomy*, Volume 14, page 14.

It is complained that several months elapsed, after the "meager" telegraphic announcement, before "we were put in full possession of the facts;" and, further, that "In the case of the Sixth Satellite of Jupiter it is quite probable that several observations would have been obtained in Europe last January if enough information had been transmitted to enable a fairly good ephemeris to be formed."

The 46-word telegram announcing the Sixth Satellite, giving position angle and distance for one date, daily rate of decrease of distance, apparent motion retrograde, magnitude, and dates of observations, contained all the information needed in photographic observations during a fortnight at least. The Washington Observatory, guided by this information, obtained a visual observaton of the Satellite. As soon as it was learned that one observer was having difficulty, the position for another date was telegraphed. A charting of the two positions, and the daily motion assigned by the first telegram, would supply intending photographic observers with all the necessary data for a fortnight ahead, to a superfluous degree. In fact, this method was the only one available for our own observations.

If Mr. Crommelin means by "full possession of the facts" a knowledge of the accurate places at all the dates of observation, we must say that very few of these were ready for our own use until after the satellites were beyond the reach of even the Crossley Reflector. And we were not ready to take the responsibility of announcing that the Seventh Satellite was a satellite until February twenty-second.

It was planned that all the details of the discoveries, all the observations of both satellites, and all that could be known about their orbits early in June, should be published in one Bulletin. We read the proofs of Bulletin Number 78, containing these data, before leaving in June for Spain, and the copies should have reached their destination early in July, before Jupiter came into observing position. Conditions over which the Observatory had no control delayed the press work on this bulletin and others for several months, and this number was most unfortunately not mailed until September, purely on that account.

A good deal of useless printed speculation is indulged in over every such discovery, with which we do not sympathize, and these cases are no exception. It has been found that orbits derived even after all the observations were available are only roughly approximate.

As to the "time and energy wasted in examining whether the

asteroid found near Jupiter by Dr. Wolf was identical with the satellite-- a question which would have been settled at once if the December positions of the latter had been available," we need only to say that no data other than those contained in the discovery telegram were necessary to decide the question. The asteroid and the satellite were several degrees of arc apart.

Mr. Crommelin's "little grumble" recalls an incident in connection with Phoebe, the Ninth Satellite of Saturn. One astronomer's kindly references to Professor Pickering's work on its orbit (soon to be published) seems to have led another astronomer to find out and to publish the most interesting fact concerning its orbit, in advance of the discoverer's publication of the same fact, already well known to him. Such an incident raises the question of the rights of a discoverer to the fruits of his labor.

Mount Hamilton, January 9, 1906.

THE MEDAL OF THE ROYAL PHOTOGRAPHIC SOCIETY AWARDED TO PROFESSOR JANSSEN.

The medal of the Royal Photographic Society was instituted in 1878. It is granted "for important advance in the scientific or artistic development of photography", and hence is called "The Progress Medal of the Royal Photographic Society". It has been previously awarded to the following persons who have distinguished themselves in the particular field herein named:—

1878.—Capt. W. de W. Abney, for his scientific work in advancing photography.

1881.—W. Willis, for the platinotype process.

1882.—L. Warnerke, for general progress of photography by his discoveries; actinometry, sensitometry; instantaneous shutter, gelatine emulsions etc.

1883.—W. B. Woodbury for stannotype process.

1884. — Dr. J. W. Eder for his work respecting gelatine chloride emulsions.

1890.—Capt. W. de W. Abney for continued experimental work and investigations in photography.

1891.—Col. J. Waterhouse, for original and continued research in orthochromatic photography, a successful process of photographic etching, and the direct production of reversed images by the use of the thio-carbamides in the developer.

1895.—Dr. P. H. Emerson for work in the advance of artistic photography.

1895.—Thomas R. Dallmeyer for the telephotographic lens.

1897.—Professor Gabriel Lippmann, for his discovery of the process of producing photographs in natural colors by the interference method.

1898.—Hurter and Driffield for their work in the determination of the speed of plates.

1900.—Louis Ducos du Hauron, for having initiated three-color heliochromy as a working process.

1901.—Dr. R. L. Maddox, as the inventor of the gelatino bromide of silver emulsion dry plate process.

1902.—Joseph Wilson Swan, for his services in relation to the carbon or pigment process and its applications in photography.

1903.—Frederic Eugene Ives, for his work in three-colored photography.

1904.—Dr. Paul Rudolph for his researches in photographic optics.

The last recipient of this prize is Professor Janssen who has now passed his eightieth birthday. This remarkable man has received many scientific honors and has occupied many positions in astronomical and photographic activity.

In 1877, the French Photographic Society conferred on him its "grand medaille" for photographic work in Astronomy. Ten years later he was President of the Academy of Sciences, and in 1893 he received the Peligot medal of the French Photographic Society whose president he was for one session.

When the Congrès International de la Photographie was founded in 1889, he was its first president, and today he fills the same office in the Union Nationale des Sociétés Photographiques de France. He is a member of the Council of the Legion of Honor, and at the present time, despite his great age, discharges the many duties which his position as a leader of Science in France lays upon him.

We are indebted to the *British Journal of Photography* Jan. 12, 1906 pp. 24, 25 for the above facts and for the just appreciation of Dr. Janssen's scientific work which has been all too briefly sketched by Leon Vidal in the following language:—

The life of M. Janssen has been devoted to astronomy, yet it is not of his purely astronomical work that one must speak, only of that part of it which is related to photography. Probably every one has a general notion of the great and valuable services which he has rendered in the application of photography to, particularly, solar astronomy, yet few are familiar with the long series of investigations dating from about the year 1874. It was

about this time that M. Janssen exhibited to the Academy of Sciences a photograph of the transit of Venus, obtained with the "photographic revolver," an instrument of his own invention, by means of which 48 images, or twice or thrice this number, could be taken. The instrument was a remarkable one for that day. It permitted of the adjustment of the total time of exposure, and of the interval between each exposure; it was automatic and, it necessary, could be held in the hand while in operation. In the same year (1876) M. Janssen made photographs of the Sun 18 inches in diameter from his observatory in Montmartre. In a communication about this time to the Academy of Sciences he forecasted the great part which photography was to play in physical astronomy:—"Celestial photography is now entering a new channel: up to now it has only been used to obtain faithful records of phenomena. It is now proceeding to the more important duties of discovering facts which escape investigation by our optical instruments." Only two years elapsed before he confirmed the truth of this prediction by photographing the "rice grain" structure on the Sun. The photograph was an enlargement to three diameters from a negative 18 inches across and made with an exposure of 1-3,000 of a second. It showed the granulations of the Sun surface and the regions where these granulations are effaced by vast rising streams of hydrogen gas.

Many other of M. Janssen's astronomical photographs must be passed over until we come to the year 1880, in which he made a communication to the French Academy of Sciences which aroused as much interest in its purely photographic respects as in its astronomical relations. It was on the reversal of photographic images by over-exposure. It was shown that in the case of the negative photographic images produced on a sensitive plate, increase of the exposure converted these images into positives.

"At Meudon," wrote Janssen, "our images of the Sun are obtained with an exposure which varies with the state of the atmosphere and the nature of the subject, but this period of exposure is rarely more than 1-1,000th second when it is required to obtain detail in the photosphere. In the case of gelatine plates, the exposure may be very much less—1-20,000 of a second and less. Under these conditions if a plate receives an impression of a half or a quarter of a second—i. e., ten or twenty million times as much, the action of the developer shows a positive—i. e., the disc of the Sun white and the spots black, as is seen in the telescope. The positive image is obtained with all the delicacy of the negative one. Between the two extremes of exposure there is a point

at which the image is neither negative nor positive—the plate is uniformly veiled—and if on the other hand, a longer exposure still is given than is necessary for the production of a positive image, this latter in turn disappears and the developer discloses only uniform transparence on the dark ground of the sky. This ground itself disappears on prolongation of the action of light." This second state of reversal which Janssen discovered in his solar photography was afterwards confirmed by Brebner and Krone.

M. Janssen himself was occupied not so much with photographic theory as with the application of this curious phenomenon, and proposed to employ reversal in obtaining photographs of the Sun's penumbra showing both the granulation and details of the chromosphere.

M. Janssen was continually applying his photography to astronomical purposes. In 1881 he read a paper on photographic photometry, taking the result of the action of light as the measure of the radiation from a celestial body. In 1893 he was at work on the spectro-photography of the chromosphere. He placed before the sensitive plate a second slit to isolate in the spectrum the particular rays forming the image. He had suggested this method so long before as 1869.

When quite an old man M. Janssen founded the observatory on the summit of Mont Blanc, and himself made the ascent of the mountain a number of times to pursue his observations in the clear and rarefied air of the highest point in Europe.

The very great extent of M. Janssen's work requires more lengthy consideration than can be given it with the space of such a review as the present one but as a last word it may again be said that he deserves to be considered as one of the most strenuous and whole-hearted exponents of photography applied, not only in a general way, but especially in scientific astronomical photography. He is one of the great men of photography.

THE MOTION OF THE MOON. *

Per Ardua ad Astra should be the motto for a cultivator of the lunar theory. There is no austerer road to prove one's self a man of mettle. *Incredibile studium atque indefessus labor* was Euler's summary upon it, and improvement of method since Euler's time has diminished neither *studium* nor *labor*. The work now brought to completion has occupied Prof. Brown (and a

* *Nature* January 18, 1906.

computer) since 1895, almost to the exclusion of other researches and for some years before that he was busied with developing its methods. Moreover, the present stage is only a level whence he can take breath to proceed.

It is a fact to remember in mathematical astronomy that problems mathematically identical are often astronomically opposite at the poles. The theory of the Moon from a geometer's point of view is simply the theory of one of the planets. It is the special values of the constants alone which distinguishes the case. The astronomer seeks a correct ephemeris, but a mathematical instinct seeks to solve the question as a case of the problem of three bodies, and Delaunay's two enormous volumes will show what labors may be undertaken to obtain full literal development of the Moon's coordinates which shall be approximate enough to meet the needs of the observer. Unfortunately the expressions when obtained are in many cases so imperfectly convergent that they give neither a solution of the three-bodies-problem nor do they surpass the observations in precision, as calculation should. It seems that unless some wholly new device is found we must be content to separate the problem into two parts, leaving literal developments for special mathematical researches throwing light upon the problem of three bodies, such as G. W. Hill's investigations of periodic moons of different mean motions, and making the developments essentially numerical when they are designed to form the basis for tables, although by so doing the former part loses all observational interest and the latter nearly all that is mathematical. Prof. Brown's theory is neither wholly numerical like that of Hansen nor wholly literal like that of Delaunay. The mean motion alone is treated as numerical, and other constants as eccentricities and inclination appearing in literal form. This was a plan Adams always urged, and from time to time he made considerable studies to give effect to it. When there otherwise remain four parameters according to powers of which each coefficient must converge, it is clearly an immense gain to omit a fifth when that fifth is answerable for all the worst cases of slow convergence; and while the mean motion may be considered known, it is hardly the case with the other constants, the lunar eccentricity, for example, and the ratio of the mean distances of the Sun and Moon being uncertain within the limits over which debate ranges so that it is essential that the calculator should not be tied to a single set of elements at the outset.

Besides this idea Prof. Brown's research rests upon two clear

and solid supports. First is the use of rectangular moving axes of reference, which he points out—and otherwise it seems to have passed from memory—was developed by Euler. But perhaps as much as anything his success is due to the brilliant transformation of the equations of motion given by G. W. Hill. It detracts not the least from Prof. Brown's achievement that his main ideas and methods are derived from earlier masters. The tools were ready to hand for one who had the learning and judgment to use them. Anyone who has faced a similar task knows that there remains abundant calls for resource and invention, as well as for comprehensive patience, in fitting given plans together and working them out abreast in every remote ramification of a subject, without fidgeting about "originality."

The work is not yet at a stage to put to proof by calculation of an ephemeris, which indeed would need the calculation of lunar places for a great many years backwards and forwards to prove that it is superior to Hansen, or to Hansen *plus* Newcomb. But even now it is almost certain that it will be so. First its methods are more intelligible and above board than those of Hansen, and so there is a better chance of correcting the errors, which no mortal can altogether escape. Next the constants are not stereotyped, and if it is necessary to change them the effect can be made visible; and for a searching piece of evidence, Prof. Brown has shown already that his calculations remove the last shred of disagreement between the calculated and observed motions of the Moon's apse. Finally, in a recent analysis of the Greenwich observations back to 1750, Mr. P. H. Cowell has given a most striking verification of all Prof. Brown's coefficient.

When Prof. Brown constructs his tables there is an error Hansen fell into which he may be trusted to avoid. In order to improve the agreement with observation, Hansen introduced a certain empirical element. An empirical correction is better than nothing, but it cannot be too clearly recognised that until it is furnished with a theoretical basis it is no more than a mathematical *memoria technica*. Certainly its place is not in a set of tables, the sole function of which is to expose correctly and fully the consequences of a clear theory and definite elements, with the view of testing the one and amending the others.

MOUNTING THE SIXTY-INCH REFLECTING TELESCOPE AT HARVARD COLLEGE OBSERVATORY.

Harvard College Observatory is at present engaged in mounting on its grounds at Cambridge, Mass., a sixty-inch reflecting

telescope recently purchased from the estate of Dr. A. A. Common of England, which will be not only the largest instrument of its kind, but the telescope of greatest aperture in active use in the world. For, while the Yerkes Observatory of the University of Chicago at Williams Bay, Lake Geneva, Wis., also has a sixty-inch mirror, for want of the requisite means it has not yet been mounted nor its efficiency proved. The telescope of A. A. Common, on the other hand, was successfully used by himself thirteen years ago, so that there is little doubt of its subsequent usefulness in Cambridge.

Very soon after the purchase of this telescope by Harvard Observatory, last year, steps were taken for mounting it in Cambridge. The site chosen is near Garden street, on the eastern slope of the hill below the main building of the observatory, and hidden by this from the view of the other buildings of the institution; here the first sod was turned Sept. 28, 1904. The small two-story wooden building that adjoins the telescope is now practically completed.

In the second story of the building is the observing-room, in which will be the eye-piece of the telescope and numerous mechanical and electrical devices for operating and controlling the instrument. On the ground floor is a room which is to be fitted with all necessary appliances for silvering the great mirror and for handling it during the operation; here, by a mechanical arrangement, the end of the iron tube which supports the mirror can be brought close to an opening which communicates by wide doors with the silvering room, and through which this massive disk of glass—nearly a ton in weight—will be rolled in over a kind of railroad onto the silvering table whenever necessary to be re-covered with a film of silver.

The construction of this building and the installation of the instrument are being carried on in accordance with the plans and under the direction of Willard P. Gerrish, of the observatory. The task of mounting the instrument, in itself an intensely interesting operation, holds special attraction for one who is interested in mechanical engineering. The mounting of a great equatorial such as Dr. Common's telescope is no simple task. In these modern days it has passed from the domain of the instrument maker to that of the engineer, who finds abundant scope for ingenuity and technical expertness in combining very massive construction with very delicate mechanism, for not only must the ponderous iron tube that supports the mirrors be so elevated and poised that there will be absolute freedom from tremor, but

the mechanism which guides it must have the greatest ease and delicacy of movement, combined with facility of directing the instrument to any desired point in the heavens.

The method of mounting the Common telescope at Cambridge is in many respects the same as that used for it in Dr. Common's observatory in Ealing, England, but the manner of operating and controlling it here is entirely new. This instrument, instead of being supported by a pier of solid masonry or by an iron column, as are many of the large telescopes at various observatories, rests upon a cylindrical steel float, eighteen feet long and seven feet eight inches in diameter, which is partly submerged in a tank filled with water, and is so ballasted that its axis points toward the celestial pole.

Delicate pivots on the ends of the float serve to steady it in this position, allowing it to turn freely on its axis, relieved of nearly its entire weight by the buoying effect of the water. At the upper end of the float is a stout fork—two steel projections securely built into opposite sides of the float—in which swings the telescope proper, a rectangular tube or structure twenty-one feet six inches long and six feet square.

The lower end of this structure for a distance of six feet is of steel plate and supports the mirror. The remainder of the tube consists of a light framework of angle iron covered with canvas to secure the greatest lightness consistent with the necessary rigidity. Two small mirrors supported at different points along the axis of the tube serve to reflect the image formed by the great mirror up to the stationary eye-piece in the observing-room.

The attention of the visitor to the site of the new telescope is first attracted to the big tank, which is protected by a high fence of matched boarding from the curious investigation of any stray idler or small boy who might find his way there. A cellar-like hole it is, with a bottom that inclines upward at an angle of about 45 degrees, and walls of solid concrete. To construct this tank a large excavation was made, fifteen feet deep at the further end and about twenty-one feet in length, with perpendicular sides.

A mold was then made of timbers and planks equal to the intended inner dimensions of the tank, and suspended in the hole by means of a wooden framework that rested on the ground above. Afterward soft concrete was poured into the space around and beneath and allowed to harden, forming a solid, immovable base. The walls have a uniform thickness of eighteen inches, the foundation at the deeper end of the tank measures six feet in concrete, and here the pivot at the lower end of the float,

PLATE V.

HARVARD'S SIXTY-INCH REFLECTOR.

on which the latter will turn, has been securely embedded; that at the upper end being attached to an iron frame, which in turn is attached to the concrete wall at the shallow end of the tank. The float is water tight, the only opening being a manhole at the upper end through which a workman could enter the great hollow cylinder, if necessary, to repair it.

The various parts of the telescope are made to fit perfectly each into its appointed place, where it is held firmly by strong bolts and rivets. For so large an instrument it is remarkably simple and ingenious in construction, the result of long and careful study and experiment on the part of its maker, Dr. Common. The idea of supporting the polar axis in a tank of water, as first put into effect and perhaps originated by Dr. Common, is an especially practical one, whose simplicity and economy in mounting a large instrument are at once apparent. But a great advance over the crude hand machinery for moving and guiding the telescope in its former mounting is being made at Cambridge. Through inventions and devices, the result of much thought and experiment on the part of Mr. Gerrish, the telescope, like no other in existence, is to be controlled and operated entirely by electricity. Small switches located at the desk in the observing-room will control motors and clutches by means of which the telescope can be swung at various speeds. A small motor, synchronized by an accurate clock, will give a uniform motion for following, while dials and indicators, also in the observing-room, will show at a glance the exact position of the telescope and the motion which is being imparted to it. Other dials will register the measures made by photometric apparatus used by the observer at the eye-piece.

Thus, while sitting comfortably at a desk in a warm room, unexposed to the weather, the observer can carry on his investigations on the coldest winter night as easily as on the pleasantest summer evening.

By merely looking down an ordinary appearing tube, inclined in a line with the polar axis to be sure, but incidentally at a perfectly convenient angle for observation, he may see all the wonders of the sky pass mirrored and magnified before him while the recorder, close by at another desk, without a physical effort beyond the touch of a button or the moving of a switch, turns the great instrument outside here or there, to reach any part of the starry sphere from horizon to horizon, as the observer directs. What more interesting or remarkable instance of twentieth century progress can be shown than in this transformation of the

rapt astronomer, as we might picture him one or two decades ago, perched on the uneasy seat of a lofty observing ladder in an icy dome, his stiffening fingers clinging defiantly to the hand levers that manipulate his instrument, his devoted mind oblivious to chattering teeth and his gaze turned eagerly skyward!

Another deviation from the old rule that has been made in mounting the Common telescope at Cambridge is the omission to protect it from the weather by a shelter or dome. First plans last year included a long, low shelter, the roof of which was to be rolled off endwise on a railroad arrangement when it was desired to use the instrument and in which the great tube was to be swung down and rested horizontally when not in use. At a serious discussion of the situation, however, it was afterwards decided by the officers of the observatory to make the experiment for at least one year of leaving the instrument uncovered. If the condensation of moisture due to atmospheric changes outside does not injure an instrument that is sheltered within a dome, it was argued, why should it suffer harm from storms? The economy and general convenience of such an arrangement, moreover, are obvious, while with a moderate amount of care the telescope can be kept in excellent condition.

The plate glass cover used by Dr. Common to protect the great mirror when not in use will be used for the same purpose here. The opposite or open end of the tube will be covered with canvas ordinarily, and the long slit in the side of the tube, through which the stationary eye-piece connects with the telescope, and which permits the latter to turn in various directions without interfering with the former, will be also closed when the instrument is not in active use.

The labor expended by Dr. Common in making the big reflector is little short of marvelous. When at last the mirror was finished it was discovered through repeated trial testings and regrindings that a strain inherent in the glass, and caused doubtless by molding it with a central hole, produced defects in reflecting the light of the stars that rendered it practically useless. Still Dr. Common persevered. In 1888 another sixty-one inch disk of glass of equal thickness, the least thickness possible to prevent flexture, and without a central hole, was ordered from the Paris house. It was delivered in Ealing near the close of 1890, when the work of grinding and polishing was immediately begun. Dr. Common was now quite an adept in the making of mirrors, so that the work progressed rapidly. In 1892 the new telescope was in use, and quickly proved by its ease of action, its great power, and its

general excellence that Dr. Common's theories concerning the practical enlargement of reflectors were altogether correct.

Professor Edward C. Pickering, Director of Harvard College Observatory, is very anxious to have the final work that still remains to be accomplished on the telescope ended as soon as possible. He is at present working with the twelve-inch telescope already mentioned. From three to four hours each night when the sky is clear is the usual time he allots to this work, when conditions are favorable, thus covering the entire sky. Cloudy nights on the other hand, and occasions when Professor Pickering finds it necessary to be absent, offer some interference. Portions of the sky thus omitted are covered when the next revolution of the celestial hemisphere makes them again visible in Cambridge.

Chicago Record-Herald, January 14, 1906.

REPLY TO THE LETTER OF PROFESSORS CAMPBELL AND PERRINE.

ANDREW C. D. CROMMELIN.

For Popular Astronomy.

The first part of the communication of Professors Campbell and Perrine is merely concerned with a difference of judgment as to the desirability of rapid publication of full details of an important astronomical discovery. I am dealing with this point in the *British Journal of the Astronomical Association* and I therefore pass over it entirely in my present letter.

The final paragraph however is of a different character, and being a very thinly veiled accusation of dishonorable conduct on my part, seems to call for some refutation. First then I would say that Professor W. H. Pickering's claims to the entire credit both of the discovery of Phoebe, and of the subsequent deduction of its orbit are unchallenged and unchallengeable. I have been second to none in expressing my admiration of the skill and patience exhibited in the detection and subsequent recovery of this extraordinarily difficult object.

But I do not admit the theory of Professors Campbell and Perrine that the discoverer of a new body is its sole proprietor, and the only person who has the right to draw deductions from observation of it that have been publicly given to the astronomical world. The heavens are the common property of all astronomers and the object of publication is unquestionably to enable others to utilize the published matter.

The peculiar feature of retrograde motion was explicitly con-

tained in these published places, and it merely needed straightforward arithmetical work to deduce it. The 'kindly references' of another astronomer, amounted to nothing more than a statement that the orbit contained an unexpected and interesting feature, and it was this that led me to undertake the work of deducing the orbit from the published position; the result interested me extremely, and as soon as I was satisfied as to its correctness I felt perfectly justified in publishing it, as being likely to interest others also. I made full acknowledgment of the sources of the observations utilized, and the rest of the work was entirely my own.

I forwarded a copy of my paper to Professor W. H. Pickering, and received such a cordial reply that I have not the smallest reason to suppose that he shares the views of Professors Campbell and Perrine, which I trust and believe are peculiar to themselves.

I even venture to think that my independent deduction of retrograde motion was of some small astronomical value; for this feature was so utterly unexpected that even after the publication of Professor Pickering's Memoir, some astronomers refused to credit it, and preferred to suppose that the object seen in 1904 was a different one from that seen in preceding years. But the fact that two entirely different methods, applied quite independently, both led to the 'retrograde' conclusion, did, I think, help to lead to the general acceptance of that result, which has been absolutely confirmed by subsequent observations and the researches of Dr. F. E. Ross.

THE DETERMINATION OF TIME FROM SINGLE ALTITUDES.

SIDNEY D. TOWNLEY.

For Popular Astronomy.

Although the principle of logarithms, to be used in performing the operations of addition and subtraction, was first set forth by Gauss a hundred years ago, it is only in comparatively recent times that the ordinary logarithmic tables have contained these so-called addition and subtraction logarithms. Such, however, is now the case and the use of these logarithms is taught in most of our most prominent colleges and universities. The principle and use of these logarithms should be taught by our teachers of mathematics at the same time that instruction in the ordinary

logarithms is given. It is to be regretted that this is usually not done.

Before tables of Gaussian logarithms were generally accessible it was the custom of writers of text-books on Spherical Astronomy to transform, if possible, all formulae to be used in numerical computations, so as to obtain the so-called adaptation to logarithmic computation. Some of our best modern text-books still cling to this custom, notwithstanding the fact that by so doing there is often a distinct loss, both as regards accuracy of results and economy of labor.

By way of illustration we may consider the case of the determination of the hour angle of a star, or of the Sun, from the solution of the familiar "astronomical triangle",—whose vertices are the zenith of the observer, the pole of the heavens, and the point on the sky occupied by the star at the instant of observation. If the latitude of the place of observation be known and the altitude of a star of known declination be measured, then the three sides of the triangle become known quantities, and it is possible to compute the three angles of the triangle by use of the formulæ of spherical trigonometry. The angle at the pole is the hour angle of the star and if the computed value of this be combined with the right ascension of the star the sidereal time becomes known.

The formula usually employed in the older text-books for the computation of the hour angle is:

$$\tan \tfrac{1}{2} t = \pm \sqrt{\frac{\sin \tfrac{1}{2} [z + (\phi - \delta)] \sin \tfrac{1}{2} [z - (\phi - \delta)]}{\cos \tfrac{1}{2} [z + (\phi + \delta)] \cos \tfrac{1}{2} [z - (\phi + \delta)]}},$$

while that used in some of the newer books is,

$$\cos t = \frac{\cos z - \sin \delta \sin \phi}{\cos \phi \cos \delta}.$$

It is seen that the second of these formulae involves the use of addition and subtraction logarithms while the first does not. Some computers think that it is a disadvantage to be obliged to use these logarithms, but I have never been able to make out of just what this disadvantage consists. It does necessitate turning to a different part of the book but in using a five-place table, such as is usually employed in problems of this kind, this cannot be looked upon as a disadvantage of any considerable magnitude.

Let us compare these two formulae. In summing up the advantages and disadvantages of formulæ it is convenient to divide the discussion into two parts: labor of computation, and accuracy of results. In considering the first of these it is not only

necessary to consider the length of time involved but also the nature of the operations performed, as some operations require more mental effort than others, and some are more fruitful sources of error than others. I have not made a special investigation of the matter, but I have the impression, from considerable experience in teaching astronomy, that students are more likely to make errors in the addition, subtraction, multiplication, and division of angles than in operations with logarithms.

A solution of this problem by the tan ½ *t* formula involves six additions and subtractions of angles and four divisions of angles. If we classify the operations according to kind we find, after canceling like operations in each method, that there remain, in the tan ½ *t* formula five divisions and multiplications of angles and six additions and subtractions of angles, and in the cos *t* formula two logarithms to be taken from the table.

In regard then to the number of operations involved, and I believe also in regard to the facility and correctness with which these operations will usually be performed, the advantage is seen to lie entirely with the cos *t* formula. I have in mind a student who worked for hours on this problem, with the tan ½ *t* formula, making mistake after mistake until he was thoroughly discouraged. I then gave him the cos *t* formula; the problem was correctly solved in a few minutes, and the student was delighted to find such an easy way out of his difficulties.

There are two other points to be considered in comparing these two formula. First: in using the tan ½ *t* formula a square root is involved and it is necessary to choose between the two roots. This is easily and instantly done by one familiar with the problem but not so by the average student. He usually takes the positive root without thinking and therefore has but one chance in two of obtaining the correct result. Of course a discrimination of a similar kind is necessary in using the cos *t* formula, in deciding the quadrant of *t*. The first, however, involves a discrimination between four quadrants, the second between two. It is readily admitted that the advantage of the cos *t* formula, in this regard, is of relatively small importance. Second: it frequently happens that $\phi + \delta$ is greater than *z* and then, if the computer should add 360° to *z* in order to keep the angle $z - (\phi + \delta)$ positive, he will presently come out with $\tan^2 t$ negative. It is an easy matter to point out the source of the difficulty but it will not readily occur to the average student.

I feel sure that anyone who has had extended experience in the use of *both* these formulæ must agree with me, that as far as

brevity and ease of computation go the advantage lies entirely with the cos t formula.

Regarding the accuracy of the two formulæ, we may profitably divide consideration of this point into two parts. First: when t, the hour angle, is greater than 52°. At 52° we find, from a logarithmic table, that the difference between two consecutive logarithms of cosines is just half the difference of two consecutive logarithmic tangents at 26°. It is therefore plain that at 52° neither formula has an advantage over the other, as far as finding the angle from its logarithmic function is concerned, for the advantage in looking out ½ t is lost when we multiply by two to form t. Beyond 52° an increasing advantage lies with the cos t formula, reaching a maximum when t equals 90°.

Second: below 52° the advantage lies with the tan ½ t formula and this advantage is very marked when t is less than 30°, and of course the cosine formula should not be used in such cases, but it is seldom necessary and never desirable to determine time from a star whose hour angle is less than 30°. Theoretically the star should be as near as possible to the prime vertical and if this condition is anywhere nearly fulfilled the hour angle will always be more than 30°, if the ordinary instruments are used.

It seems then that the general statements concerning the superior accuracy of the tan t formula are misleading, and it is rather odd that we should find authors who use it exclusively, since the computation is always much longer and more difficult and in many if not the majority of cases, the results are *less* accurate than when the cos t formula is employed.

If the sin ½ t formula be substituted for the tan ½ t formula the above remarks concerning the length and facility of computation still apply but with less force. As to accuracy, however, the cos t formula has a still greater advantage as the dividing line is near 48° rather than 52°.

International Latitude Observatory,
Ukiah, Cal.

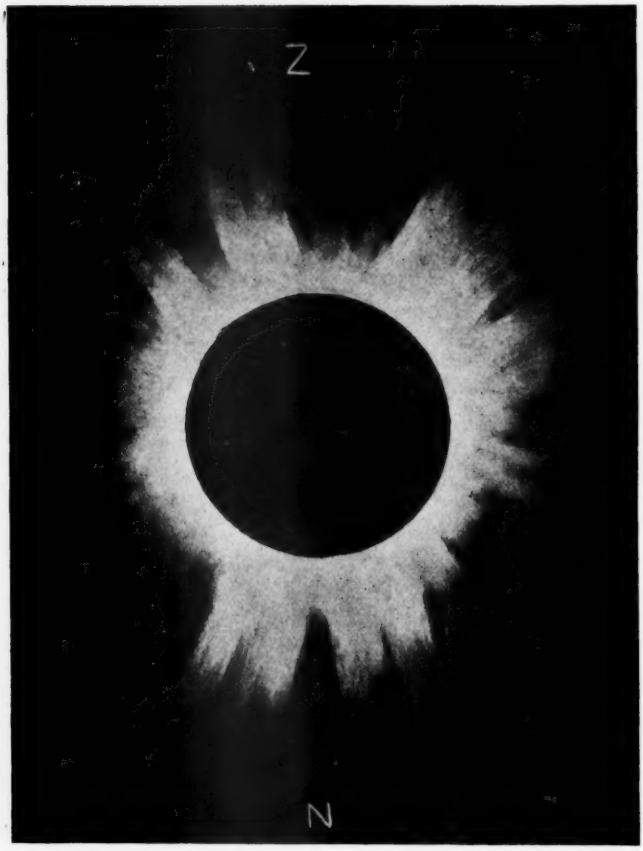
TOTAL SOLAR ECLIPSE VIEWED AT BURGOS.

V. VENTOSA.

FOR POPULAR ASTRONOMY.

We made our observations in the camp of Libaila at Burgos, close to the Belgian expedition of which I was a member.

From the time I left the observatory of Madrid my means of



THE SOLAR CORONA, AUGUST 30, 1905.

(A Photographic reproduction, without retouching, of a drawing made by V. Ventosa.)

observation being very restricted, I was obliged to limit my program, aside from the drawing of the corona, to the determination of the times of contact. This we did by observing with one of Busch's binocular prismatic glasses of good optic qualities, magnifying twelve times linearly, an eye-piece tinted for observation of partial phases, the other free and utilizable during totality; The time was noted by means of a watch of precision and by a reckoner of seconds put in movement and stopped at the instants of contact.

Since the sky grew more and more cloudy as the day advanced the first and last contacts were lost. But in the middle of the eclipse an opportune clearing allowed us to observe the totality and I was able to determine the time corresponding to the second and third contacts. Here they are given in civil mean time of Greenwich:

Second contact at $13^h\ 6^m\ 40^s.6$
Third contact at $13^h\ 10^m\ 22^s.1$.

According to these numbers it is seen that the contacts occurred about seventeen seconds earlier than the hour calculated, the duration of totality not being noticeably changed. This remarkable result was also found in various stations in Spain and even in Algeria. The accompanying illustration is a reproduction of a photograph of a drawing of the corona made by my son.

Madrid, Spain, January 2, 1906.

ASTRONOMY.*

E. W. MAUNDER.

The Sun. The most interesting advances in astronomy during the year 1905 have lain in three special directions. First in solar physics, next in lunar theory, third in satellite discovery. In solar physics it should first of all be noted that sun-spot activity has undergone a very marked development indeed. The largest sun-spot as yet photographed at Greenwich Observatory appeared at the east limb of the Sun on January 28, and passed off at the west limb on February 11. This was the second appari-

* The Summary of the Advance in Astronomy for the year 1905, as presented in the *Science Year Book* for 1906 by E. W. Maunder of the Royal Observatory, Greenwich, England is the best and most complete that has come to our notice from any other source. A considerable portion of this annual review is given below, for the benefit of our readers because of its conciseness, its value and its breadth of view.

tion of the group and on February 2, it attained an area of 3,339 millionths of the Sun's hemisphere. During its third apparition, February 25 to March 10, another great group appeared, but in the northern hemisphere instead of the southern. A third enormous group ran its course in the middle of July, and a fourth during the latter half of October. These four great groups quite rival the largest seen during the last maximum, 1892-4, but apart from the four, the average spot activity has not reached the level which it did in the last cycle. The increase in number and extent of faculæ and prominences closely accorded with the increase in the sun-spots; the activity of the first quarter of 1905 being much more marked than the second quarter.

Rotation of the Sun. Two determinations of the speed of rotation of the Sun have appeared during the past year. The first of these is by Dr. J. Halm, in which he employed the spectroscopic method devised by Professor Dunér, the displacement of two solar lines being measured with respect to two telluric lines in the spectra of the Sun's limbs. This spectroscopic method has two great advantages over determinations made from observations of the solar spots, in that it is free from the very considerable effect of the proper motions of the spots, and is not restricted to latitudes lower than 40°. Dr. Halm found, as Professor Dunér did before him, that the angular velocities diminished steadily from the equator to the poles, but he was not able to represent these velocities by any sine and cosine functions of the latitude. The purely empirical formula at which he arrived, was quite of a novel form, namely,

$$\xi = a - bc\beta$$

where ξ is the angular velocity in latitude β; and a, b, and c are constants.

A very striking result of the investigation is, that these constants appear to vary from year to year. The observations made by Professor Dunér during the minimum of 1887-1889 agree almost precisely with those found by Dr. Halm during the minimum of 1901-2. But the year 1903, when the solar activity was quickly reviving, showed a great change in the values of a and b, the retardation of the higher latitudes being now reduced to less than half its minimum value. This is a very striking result, and astronomers will look forward with great interest to the continuance of the observations through the present maximum, in order that this conclusion may be completely tested.

The other determination of the Sun's rotation was by the writer and Mrs. Maunder and depended upon the Greenwich sun-

spot measures for the years 1879-1901—two complete solar cycles. The results obtained show that Carrington's mean rotation period of 25.38 days is somewhat too long, and that his expression for the retardation of latitude was unnecessarily complex. The mean sidereal period given by the sun-spots of long duration was found to be 25.2 days, and the formula for the variation of the rotation period of latitude, $866.6—128 \sin \lambda^2$. But the rotation periods given by different spots in the same zone of latitude differ more widely than do the mean rotation periods for different zones of latitude up to 35°. Contrary to the result found by Dr. Halm, and noticed above, no evidence was found of a progressive change in the mean rotation period during the progress of the sun-spot cycle, other than that which follows from the gradual shift of sun-spot activity from higher to lower latitudes.

Sun-Spots and Magnetic Disturbances. The demonstration of the solar origin of magnetic disturbances by the writer about a year ago, has been under discussion by Professor Schuster, Professor Larmor, Father Cortie, Mr. Dyson, Mr. Ellis, and Dr. Chree. Further evidence from the magnetic disturbances recorded at Greenwich during the years 1848-1881 has also been brought forward by the writer.

Sun-Spot Spectra. Several important observations in this field have appeared during the year. Mr. W. M. Mitchell, of Princeton Observatory, has published his observations for the year ending March, 1905, dividing his observations into two parts: (1) The nearly continuous spectrum of general absorption, and (2) the superposed array of effective Fraunhofer lines. The band-lines into which the nearly continuous absorption spectrum can frequently be resolved, were first seen in 1880 by the writer at Greenwich, and Mr. Mitchell confirms the view which the writer then expressed, that they were not present in the ordinary photospheric spectrum at all. In discussing the Fraunhofer lines which are affected, Mr. Mitchell agrees with Young, Cortie, Hale, and Lockyer, that vanadium and titanium are the most important elements concerned, but manganese is also largely affected. The great sun-spot of February this year showed a striking change in the behavior of certain manganese lines, as observed on February 3, and on March 3, being strongly reversed on the former occasion, but on the latter no longer reversed, but excessively wide and hazy. Mr. Mitchell is inclined to the opinion that sun-spots are probably caused by the heated vapors of the interior slowly oozing through the vaporizing clouds of the photo-

sphere. The sun-spots are at least below the level of the chromosphere and are probably regions of relatively high temperature. High level chromospheric lines are not affected in spots, and lines greatly affected in spots are seen but rarely in the chromosphere.

The great sun-spot of February, 1905, was also examined spectroscopically by Professor Fowler and by Father Cortie. It proved an exceptionally interesting object, in the reversals of lines which is exhibited, and in the brilliant prominences seen above it when it reached the west limb.

Dr. W. E. Wilson has communicated to the "Monthly Notices" an important paper on the spectrum of an artificial sun-spot, in which he showed that the mere reduction of the brightness of the continuous spectrum was sufficient to cause an increase of breadth and darkness in the absorption lines caused by the superincumbent absorbing vapors. He considers that in a sun-spot this diminution in the brightness of the photosphere is brought about by rise of temperature, so that even carbon is volatilized, and we are enabled to see below the photospheric clouds. In the Sun there would seem to be two distinct layers giving a continuous spectrum, first the photospheric clouds, and next, some depth below, a layer of gases of sufficient thickness and pressure to be opaque. Between these two layers lie the vapors of titanium, vanadium, and other similar elements. A sun-spot then would be a local upheaval of the high temperature, proper to the lower stratum, bringing about the volatilization of the carbon, and revealing the lower, less brilliant shell of opaque gases. The widening and darkening of the sun-spot lines is partly due to the feebler continuous spectrum, and partly to the greater depth of the vapors of titanium and kindred elements. Extending this reasoning to spectra, it would seem that brilliancy *per se* is no criterion as to the temperature of the star, and that if the solar temperature were raised a certain amount its brilliancy would probably fall 50 per cent., and its spectrum become almost identical with the fourth type stars, which should, therefore, not be classed as cooler than the Sun, as has been generally done, but as hotter. On the other hand, if the solar photosphere was of sufficient depth to be quite opaque, that is to say, if there were a wider region in which the temperature was sufficiently low to permit of the condensation of carbon, and if the vapors of the elements below the photosphere were not carried to the surface by convection currents, we should have a spectrum recalling that of Sirius, which should, therefore, be taken as slightly cooler than the Sun, and not at a higher

temperature.

The Spectroheliograph. Amongst the papers, dealing with this instrument, which have appeared during the year are two by Professor Hale and Mr. Phillip Fox respectively, on the question as to how far the faculæ seen visually are identical with the floculi obtained with the spectroheliograph. Mr. Evershed, in April, 1904, had expressed his opinion that photographs taken with the second slit near the edge of the broad H and K lines correspond rather to the true faculæ than to a low-level calcium vapor. Professor Hale urges that, if the objects photographed with H or K light were the faculæ, their forms should remain the same whether the second slit be set on the continuous spectrum or at any point on the H or K bands. Mr. Fox, a month later, reproduced a set of photographs in the "Astrophysical Journal," showing the way in which the floculi change both in form and area as the center of the H line is approached. With the second slit set midway between the H and K lines, the photographs were very similar to direct photographs of the Sun so far as the faculæ were concerned. With the slit moved to wave length 3962.2, these faculous markings appeared sharply defined, even as far as the centre of the disc, and the agreement in form to the faculæ appeared to be perfect so far as they could be compared. No change in form was detected until wave length 3965.5 was reached. From this point on to the center of the H line, the change in form, size, and contrast is progressive, at first slow, then rapid.

A large spectroheliograph has been erected at the Solar Physics Observatory, South Kensington, and Dr. Lockyer, having overcome the many and great difficulties which attend the inception of work with this instrument, has been able to present to the Royal Astronomical Society a number of very successful photographs, showing both the disc of the Sun in K light, photographs of prominences in K light and also composite photographs showing both disc and limb. A pair of photographs taken on July 14, 1904, showed a remarkable change in a large prominence in the interval of an hour of time.

The Observatory on Mount Wilson. A most important step for the advancement of astronomy has been taken by the establishment of a Solar Observatory on Mount Wilson in Southern California, at an elevation of about 6,000 feet, in an atmosphere free, through exceptionally long periods, from cloud, water vapor, dust or fog, or wind; its position is in latitude 34° 13′ 26″ and longitude 180° 3′ 40″; and is not far distant from the cities of

Pasadena and Los Angeles. The plan of work proposed includes the following classes of observation: 1, Frequent measures of the heat radiation of the Sun, to determine whether there may be changes during the sun-spot cycle in the amount of heat received from the Sun by the earth, and in the relative radiation of the various portions of the solar surface. 2, Studies of various solar phenomena, particularly through the use of powerful spectroscopes and spectroheliographs. 3, Photographic and spectroscopic investigations of the stars and nebulæ with a very powerful reflecting telescope, for the principal purpose of throwing light on the problem of stellar evolution. There will be an attempt to realize more completely laboratory conditions in astrophysical research through the employment of fixed telescopes to the coelostat type, and through the adoption of a coudé mounting for the 5-foot reflector, which will be one of the chief instruments employed. This would permit the use of mirrors or objectives of great focal length, providing a large image of the Sun for study with spectroscopes and spectroheliographs; the use of long-focus gratings mounted in a fixed position in constant temperature laboratories, and the use of various laboratory instruments, such as the radiometer, which cannot now be used with a moving telescope. The observatory will also have a workshop for the providing and designing of new instruments, and for the repair or adapting of the older telescopes.

The Yerkes Observatory has lent the Snow telescope, which is already installed on Mount Wilson; this instrument will eventually be returned to the Yerkes Observatory when the Mount Wilson workshop has provided its observatory with a similar instrument. The Bruce telescope has also been installed on the mountain during the summer of 1905, and Professor Barnard has been engaged with it in completing his photographic studies of the Milky Way.

The present staff consists of Professor Hale the director; Professor G. W. Ritchey, astronomer and superintendent of instrument construction; and Professor Ferdinand Ellerman and Professor W. S. Adams, assistant astronomers.

The Solar Parallax. From the discussion of 300 exposures on Eros at nine different observatories, and on nine days in November of 1900, Mr. A. R. Hinks deduces a solar parallax of $8''.797 + 0''.0047$, corresponding to a distance of the earth from the Sun of 92,928,000 miles. This would mean that the value of the constant of aberration would be very nearly $20''.48$.

Professor Doolittle, of the Flower Observatory, Pennsylvania

who has devoted himself a great deal to the determination of this constant of aberration, has published in the *Astronomical Journal*, No. 571 a value 20″.54 as the result of more than 15,000 determinations. Professor Doolittle remarks that no reasonable changes in weighting will alter this result more than 0″.01. In 1903 Dr. Chandler stated, as the result of a very complete investigation, that the real value is likely to be found near or slightly above 20″.52.

Total Solar Eclipse of August 30. An unusually large number of expeditions were sent out to observe this eclipse, and the line of stations extended from Lake Winnipeg, in the west, to Assouan, in the east. Unfortunately the weather was unfavorable in an unusually large proportion of cases. Thus, in Labrador, nothing was seen of totality at either the station in the interior, occupied by the Canadian astronomers and one of the Greenwich parties, or at the station at Cartwright, on the coast, occupied by the observers from the Lick Observatory and from Newfoundland. In Spain Mr. Evershed, at Burgos, and Professor Callendar's party, at Castellon, were equally unfortunate, and Sir Norman Lockyer was but little better favored at Palma, Majorca. Amongst the fortunate stations was Guelma, in Algeria, where Mr. Newall and M. Trépid had superb weather conditions. Mr. Buchanan was equally fortunate at Torreblanca, on the east coast of Spain. Sir William Christie, at Sfax, in Tunis, was troubled with some amount of passing cloud; nevertheless, a fine series of photographs was secured. At Assouan, where Professor Turner and one of the Lick Observatory parties were stationed, the atmospheric conditions were perfect, except for a slight haze. At Tripoli, Professor D. P. Todd, Professor Millosevich, and M. Liberd, of Paris, had clear skies. The parties of the British Astronomical Association at Burgos had it clear for part of totality, an experience which they shared with one of the parties at Palma. Some other members of the Association, a little further from Palma, were much more fortunate, and saw totality clear throughout.

It is especially to be regretted that the Labrador expeditions met with bad weather since at both stations arrangements had been made to duplicate, with instruments identical with those used in Egypt, the coronal photographs taken by Professor Turner and the Lick observers at Assouan, and thus to obtain preeisely comparable representations of the corona from stations as widely separated as possible.

The general appearance of the corona, as observed at the more

favored stations, was that of fully developed "maximum" type, the streamers radiating in all directions. One of the longest of these extended towards Mercury for more than three degrees. The lower corona was very brilliant for about half a radius from the limb. Dr. J. Larmor reports that some of the streamers seemed to cross, and were certainly not all radial. A magnificent group of prominences was seen on the east limb of the Sun. Numerous observations were made by means of color screens, Mr. Blum, of the French expedition to Burgos, obtaining two photographs through screens which only transmitted the gaseous radiation of the prominences. M. d'Azambuja, at the same place, measured the coronal radiation, obtaining figures decidedly smaller than those recorded in 1900. M. Salet, at Robertsville, Algeria, found a slight deviation amounting to about 29.5 of the plane of polarization of the coronal light, which seems to show that, in spite of its great mass, the Sun has only a small magnetic field. A photographic study of the polarized light of the corona showed the bands of polarization to decrease in intensity to about one and a-half diameters from the solar limb, the maximum intensity occurring at about 6″ from the limb. A prominence extending across two bands showed no difference of intensity.

The Corona in Full Sunshine. It is now more than twenty years since Sir William Huggins believed that he had succeeded in photographing the corona without an eclipse. His experiments, however, received no confirmation from the eclipse of 1886, and he withdrew his claim. Since then a great number of attempts have been made to obtain this much-desired result, the latest being one by M. Hansky from the observatory on top of Mont Blanc. His photographs were taken through a screen which absorbed all rays more refrangible than λ 6,600. In other words, only the red end of the spectrum was used. Direct rays from the Sun itself and its chromosphere were shut off by interposing a black disc. Faint halos were seen on the resulting negatives, and M. Hansky considered that these were truly coronal in character. This can only be a matter of opinion until the method has been practically tested during an eclipse.

TWENTY-FIVE NEW VARIABLE STARS.

E. C. PICKERING.

A recent examination, by Miss Henrietta S. Leavitt, of plates taken with the 24-inch Bruce Telescope, has led to the discovery

of a number of new variable stars, which are given in Table I. The six variables in Orion were discovered during the selection of comparison stars for the pair of variables, H 797 and H 798, near σ Orionis. The discovery of the three variables in Virgo was made by superposing plates in the manner described in Circular 79. Six excellent plates, having exposures of about two hours, were used. The approximate centers of these plates are R. A. = $13^h\ 54^m$, Dec. = $-10°$. (1900). The known variable, RR Virginis, was re-discovered at the same time. The sixteen variables in Cygnus are in the region of the great spiral nebula, whose most conspicuous portions are catalogued as N. G. C. 6960 and N. G. C. 6992. Together with the known variable UX Cygni, they were found by superposing five plates having exposures of from two to four hours. Of these, three have centers near R. A. = $20^h\ 45^m$, Dec. = $+30°.5$, while those of the other two are near R. A. = $20^h\ 50^m$, Dec. = $+32°.5$. All the plates are of extremely fine quality, and probably the images of at least 200,000 stars were clearly seen and compared. The successive columns of the Table give the Harvard number, the constellation, the right ascension, and the declination for 1900, the brightest and faintest magnitude so far observed, and the range.

The positions of the new variables in the Small Magellanic Cloud, as announced in Circular 96, have been measured, and observations of their brightness are in progress, with a view to determining their light curves. New variables are occasionally found in the course of this study, the number discovered in this region up to the present time being 970. A series of excellent plates covering the large Magellanic Cloud has been received, and a preliminary examination indicates that it also contains variable stars in very great numbers. The study of this region is being carried on simultaneously with that of the small Magellanic Cloud.

TABLE I.

NEW VARIABLE STARS.

Harvard No.	Constellation.	R. A. 1900	Dec. 1900	Br.	Ft.	R.
		h m s	° ′			
1176	Orion	5 33 26	— 2 49.5	15.6	<16.4	0.8
1177	Orion	5 33 58	— 2 51.2	14.1	<16.4	2.3
1178	Orion	5 34 25	— 2 43.6	15.0	16.3	1.3
1179	Orion	5 34 38	— 2 24.1	14.5	16.0	1.5
1180	Orion	5 34 38	— 2 34.6	15.0	15.5	0.5
1181	Orion	5 34 40	— 2 46.2	14.4	16.0	1.6
1182	Virgo	13 50 20	—10 43.8	14.0	15.0	1.0
1183	Virgo	13 51 32	—12 4.3	13.0	14.0	1.0
1184	Virgo	13 58 49	— 9 31.2	13.0	14.0	1.0

TABLE I.—(Continued.)

NEW VARIABLE STARS.

Harvard No.	Constellation.	R. A. 1900			Dec. 1900		Br.	Ft.	R.
		h	m	s	°	′			
1185	Cygnus	20	40	29	+31	58.0	14.1	14.7	.60
1186	Cygnus	20	42	27	+30	36.2	14.2	15.0	0.8
1187	Cygnus	20	42	42	+31	23.9	13.6	14.3	0.7
1188	Cygnus	20	43	8	+30	50.4	12.6	14.1	1.5
1189	Cygnus	20	43	30	+31	21.8	13.8	14.9	1.1
1190	Cygnus	20	44	0	+32	42.5	14.0	14.9	0.9
1191	Cygnus	20	44	56	+31	28.8	10.5	12.5	2.0
1192	Cygnus	20	47	21	+33	25.9	12.0	<15.5	3.5
1193	Cygnus	20	47	41	+31	46.2	12.9	16.0	3.1
1194	Cygnus	20	50	18	+30	14.0	11.5	13.7	2.2
1195	Cygnus	20	52	5	+33	19.1	13.4	15.3	1.9
1196	Cygnus	20	52	6	+32	23.2	14.1	<16.5	2.4
1197	Cygnus	20	52	59	+30	56.8	12.5	15.5	3.0
1198	Cygnus	20	53	8	+32	49.6	13.0	15.2	2.2
1199	Cygnus	20	59	17	+32	40.0	12.5	13.7	1.2
1200	Cygnus	21	45	8	+29	40.0	13.0	14.4	1.4

THE TRANSPARENT COSMIC MASSES OVERWEIGH THE STARS THEMSELVES.

AD. VON BRANDIS.

FOR POPULAR ASTRONOMY.

A few plain arithmetical calculations are needed to sustain this proposition.

It is generally accepted that some transparent gaseous matter must fill the space between the stars as a conductor of light.

It is shown that the proposition is valid when that transparent mass consists of the lightest matter exclusively; then it will be the more valid if mixed with heavier gaseous matter.

The lightest matter is etherion. At the surface of the Sun its theoretical density is about 57,653,000 times less than that of the Sun's mass,* and that is at a distance of one Sun's radius, or of about 428,000 miles from the center of the Sun.

Farther away from the center the density of gaseous matter

* The density of the Sun is 1.4 times that of water; the density of water is 770 times that of the atmosphere at sea level; and the density of the atmosphere is 1,444,000 times that of etherion.

At a distance of one Sun's radius from the Sun's center the theoretical density is 27 times greater than at the Earth's sea level.

Dividing by 27 the product of the three upper values, that 57,653,000, referred to at the beginning is obtained.

decreases in the square of the distance, while the capacity of spheres increases in the cube of the radius or distance from the center.

Dividing the cube by the square of a radius it follows that spheres of etherion around the Sun contain masses in the plain proportion of radius to radius.

Therefore a sphere with a radius 57,653,000 times longer than the radius of the Sun, or 24,675,000 millions of miles long, contains a mass of etherion equal to once the Sun's mass.

This creates a convenient basis for comparison of the masses of etherion in spheres around the Sun for any chosen radius and also for heavier mixtures.

As many times as 24,675,000 millions of miles (or 4.2 light-years*) are contained in such a radius, as many times its sphere contains more mass than the Sun. As 4.2 light-years do not reach yet even the nearest star, which moreover is, like the Sun, a center of increased densities, the proposition is sustained.

W. W. Payne (in *Popular Astronomy*, 1903, vol. II, pp. 411-417) shows that spheres around the Sun with radii of respectively 1, 2, 3, 4 (and more yet) units of six light-years, include respectively 1, 8, 27, 64 stars, thus the cube numbers of their units, which indicates considerable regularity of distribution in space.

Those above quoted 4.2 light-years as a radius of an etherion sphere is about 5.7 times in 24 light years, which as the radius of a sphere assigns to it 5.7 times the mass of the Sun.

The 64 nearest stars included therein do not affect that figure, generally expressed, because dividing by that number and at the same time multiplying it thereby, for more mass and centers of increased densities, leaves it 5.7 more mass of etherion than the combined mass of Sun and 64 stars.

For hydrogen instead of etherion the 5.7 would become 570,000.

In relation to the subject it may be remarked that the attractive forces of the transparent masses, from any point in all directions about equally strong, generally, are neutral in effect, and do scarcely affect the mutual attractions of the stars amongst themselves.

For the sake of simplicity minor questions, such as temperature, can safely be ignored, thereby adding considerably to the clearness of the fundamental proposition viz:

"The transparent cosmic masses overweigh the stars themselves.

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* A "light-year" is a distance 63,000 times the distance from the Earth to the Sun, which latter is about 93 millions of miles.

THE SIZE OF THE STARS.

W. W. PAYNE.

An interested reader of this publication desires information regarding the size of the first magnitude stars as compared with the Sun.

In attempting to answer such a question, it will be necessary to refer to the methods used by practical astronomers in obtaining such data, that the reader may know for himself how the work is done, and that he may form some judgment of the accuracy of results that are possible under the circumstances.

In the first place, no star in the heaven is near enough to the Earth to show a real, or a measurable disc in the largest telescope in the world. By the aid of the telescope observers do see what is called the spurious disc of any bright star, and astronomers know that this apparent, or spurious, disc is caused by "the wave nature of light," which prevents the image of the star from appearing to be what it really is, viz: a luminous point; but shows it as a circular spot of light varying more or less in color and often fringed with spangles which give an unsteady and blurred appearance, quite unsatisfactory to the practised eye that would make a study of its color and spurious disc.

When the atmosphere is unusually steady, a good telescope makes this spurious disc a thing of beauty and of much interest.

In the more favorable "seeing" this confused disc of the star becomes bright at the center and fades away regularly towards its edge, outside of which is a series of bright rings, the nearest one, only, being seen usually. This ring-and-disc system is useful because, by its measurable size, and the known values of the wave-lengths of light, observations may be taken of them with large or small telescopes, and the predicted size of the rings should correspond to those measured by any telescope of a known clear aperture.

What may seem curious to the ordinary reader is the strange fact that the spurious disc of a star diminishes in size as the telescope is increased in size and clear aperture. In a telescope with an object-glass of one-inch in diameter the apparent disc of the star should be 4″.5 in diameter; in a 4½-inch telescope, it should be 1″, in a 9-inch objective, 0″.5, in an 18-inch glass,

0″25; in the Lick Telescope (36 inches) 0″.11. Under most favorable circumstances three concentric rings have been seen, separated by distances somewhat greater than the diameter of the spurious disc.

In favorable seeing (which is rare) the telescope which will show this apparent disc perfectly sound without "wings or tails of any kind" will also bring out the ring system and that is a good test for the defining power of the instrument.

Amateurs who may be trying their telescopes should not use too high powers in this kind of star observation. Something less than 50 to the inch of aperture is likely to be better than any power higher, for reasons that will be obvious to those having but little experience.

We have said this much preparatory to answering the query made in the outset. It is apparent from what has been said that any direct measures of the apparent disc of a star will give no aid in telling either its size or its distance. Astronomers first try to find out how far a star is from the Earth and after that a study of the size is undertaken. The principle employed to get a star's distance is essentially that used by a surveyor to find the distance between two inaccessible objects. He lays down a base line, very carefully measures it, then measures angles needed to know triangles formed by the base-line and the two inaccessible points; then by the principles of trigonometry the distance between the two points desired can be easily and accurately computed, if those principles have been applied most effectively. When we wish to measure the distance of the Sun from the Earth, the Earth's diameter, about 8000 miles, is made the base line; but when we measure the distance of a star the diameter of the Earth's orbit around the Sun is chosen for the base line, 186,000,000 miles. If the astronomer should measure the distances of a star from others near by on the first day of January and then measure the distances between the star on July 1, of the same year, he might find some very small changes due to the fact that the Earth has changed its place in the heavens 186,000,000 of miles during the six months that have intervened. If there is such an apparent displacement of any star sufficiently large to measure, such displacement is called the parallax of the star, which is measured in seconds of arc. It is then very easy to find the distance of the star. This is done by multiplying the distance of the Sun from the Earth by 206,265, the number of seconds of arc in a radian and dividing the product by the parallax of the

star, which will give the result in miles, for the distance of the star.

All such distances in miles are so very large that they can not be comprehended at all. The mind can not form any idea from such a long continuous array of figures. On this account astronomers have adopted a new unit of stellar distances called the light-year, which means simply the distance that light will travel in one year, its velocity being about 186,330 miles per second. It requires 499 seconds of time for the light to reach the Earth from the Sun, a distance of about 93,000,000 of miles. In a year then, light will go 63000 times as far as the Earth is from the Sun. It will be readily understood that if any star should have a parallax as great as one second of arc (1″), its distance would be 3.26 light-years. The meaning of that is, if light should start from such a star it would not reach the Earth until 3.26 years had passed. In other words the light by which one sees such a star now, would have been on its way to the Earth more than three and one-fourth years. But the fact is that there is no known star that has a parallax as great as one second of arc. The nearest known star is α Centauri and its distance is probably not less than 4.3 light years. Other stars that have been observed for parallax give distances varying from 8 to 30 light-years, but the errors are so large in this exceedingly difficult work that most of the results so far obtained can not be considered worth more than fair approximations to their exact distances. About one hundred stars have been observed for parallax, and it is just to say that about thirty of this number have a known parallax that would stand, on the average, as a good first approximation.

The size of a celestial object in linear measure depends manifestly on its distance. This is why the reader's attention has been called to the difficult problem of measuring the distances of the stars.

Now if stellar distances are not known correctly, much more will we be unable to know exactly their real diameters even if we could see, by the aid of the telescope, their real discs instead of the spurious ones. But, since we can not even see any appreciable real disc to measure, some other way must be found to get at the actual size of these great luminaries set far away in the depths of space.

The only way now open to the astronomer is through the masses of binary stars when we know both the size of the orbit

of a binary and its period. The mass is then determined by the law of gravitation. This at once raises the question what is meant by the size of a star. If its volume in space is meant very little if any thing can be said. If the masses of the stars are in question, then some of the binaries can be determined, for example the Algol system as a whole is known as well as it can be considering the uncertainty of parallax, and a slight error in parallax will give a vastly greater error in mass, at least three times as great as linear errors are.

In these binaries, the astronomer can not know anything about the masses and densities of the separate components in the systems; he can only get an approximation of the average mass of the entire system.

The spectroscopic binaries furnish an interesting class of stars whose masses may be compared with our Sun. Work has been done in this way on η Cassiopeiæ, Sirius, α Centauri and 70 Ophiuchi.*

This list is extended to twelve in number by more recent work.†

The details of results in this direction are many and extremely interesting within the limits of reasonable probability.

We have said nothing about the brightness of stars as compared with the Sun. When the distance of a star is known a simple law of physics enables us to get the brightness of it. In this way it is easy to learn how many times as bright any star may be as compared with any other star; but all these comparisons do not necessarily determine their relative sizes or masses as will be readily understood from what has already been said.

THE IDEAL.

All filled with stars is the heaven fair.
Earth shimmers in the Moon's pale beam,
The soul of the world seems in the air.
I'm dreaming of the star supreme,
The one our eyes can never know,
But yet whose light is on the way
And will surely come to this world below
To charm the eyes of a future day.
And when one day a light shall shine
Than all the rest more bright, more far,
Ye mortals that on Earth still pine
O tell my love to the wondrous star!

—SULLY PRUDHOMME.

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* See Young's Manual of Astronomy, p. 542.

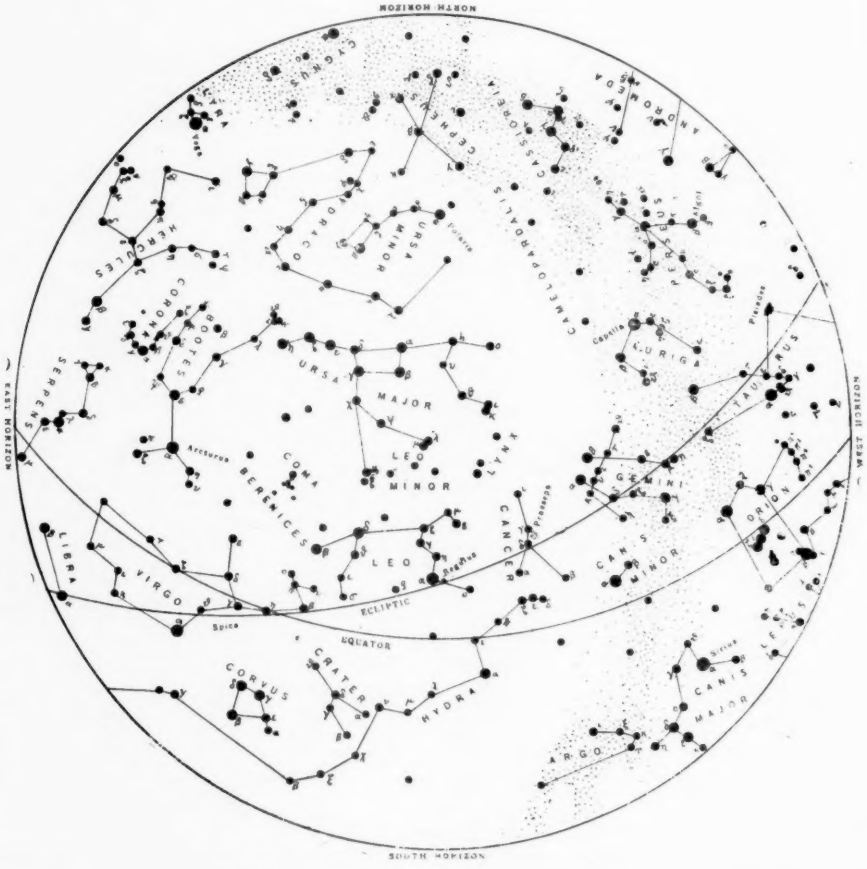
† See Clerke's System of the Stars (revised), p. 382.

PLANET NOTES FOR APRIL 1906.

H. C. WILSON.

Mercury will be at inferior conjunction April 4, and visible as morning star during the last week of the month of April. In the February number of *Popular Astronomy* we inadvertently wrote "morning star" instead of "evening star" in the note on Mercury for March. The planet will be visible in the evening during the middle of March.

Venus is evening star, but not far enough from the Sun for satisfactory observation during April. The planet may be seen almost due west soon after sunset.



THE CONSTELLATIONS AT 9 P. M. April 1, 1906.

Mars has been climbing the slope of the ecliptic rapidly during these last months and, in the latter part of April, will be just a little south of the Pleiades. All the time the Sun is steadily, although slowly, gaining on Mars so that toward the end of the month the planet will set only an hour and a half after the Sun. Venus and Mars will be near each other in the latter part of April but will not come into conjunction until May 6.

Jupiter may be observed during the evening twilight during this month. The planet is between the Hyades and the Pleiades and is moving slowly eastward.

Saturn is a morning planet now, being on the meridian about two hours before the Sun April 1.

Uranus is near the meridian, in the constellation Sagittarius, at six o'clock in the morning. It is not yet in favorable position for observation, but may be seen with the aid of a telescope in the morning hours.

Neptune is past its best position for the year, but may be studied with the aid of a telescope in the early evening hours. It is to be found in the constellation Gemini among the faint stars about four degrees east from the star μ.

Occultations Visible at Washington.

Date 1906.	Star's Name	Magnitude.	IMMERSION. Washington M. T.		Angle f'm N pt.	EMERSION. Washington M.T.		Angle f'm N pt.	Duration.	
			h	m	°	h	m	°	h	m
Apr. 2	q Geminorum	5.0	11	16	77	12	14	309	0	58
6	σ Leonis	4.2	9	40	168	10	29	246	0	49
8	65 Virginis	6.0	15	07	115	16	13	291	1	06
8	66 Virginis	5.7	15	54	136	16	51	267	0	57
13	21 Sagittari	5.0	15	06	78	16	24	293	1	18

Phenomena of Jupiter's Satellites.

[Central Standard Time.]

The hours after Midnight are numbered 12h, 13h, 14h, etc.

	h	m			h	m	
Apr. 2	7	24	I Oc. Dis.	Apr. 13	7	38	III Oc. Dis.
3	6	46	I Tr. Eg.	14	7	45	II Sh. In.
	7	48	I Sh. Eg.		8	38	II Tr. Eg.
5	7	56	II Oc. Dis.	17	8	33	I Tr. In.
6	7	27	III Ec. Dis.	18	8	57	I Ec. Re.
7	7	49	II Sh. Eg.	21	8	47	II Tr. In.
10	6	33	I Tr. In.	23	7	9	II Ec. Re
	7	30	I Sh. In.	24	7	44	III Sh. Eg.
	8	48	I Tr. Eg.	25	7	56	I Oc. Dis.
	9	44	I Sh. Eg.	26	7	19	I Tr. Eg.
11	7	02	I Ec. Re.		8	3	I Sh. Eg.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., denotes occultation; Tr., transit of the satellite; Sh., transit of the shadow.

COMET AND ASTEROID NOTES.

New Comet *a* 1906.—The first new comet of this year was discovered by Prof. W. R. Brooks, of Geneva, N. Y., on the evening of January 26. It was then in the constellation Hercules near the star τ. It has since then according to the ephemerides which are given below, moved rapidly northward until it passed the pole and it is now going southward toward the opposite part of the heavens. The accompanying diagram shows to the eye the relative positions of the comet and Earth and readily explains the rapid motion across the heavens. It will be seen that the comet was at perihelion a month before it was discovered, and that up to about the 10th of February the Earth and comet were approaching each other, but that they passed by each other many millions of miles apart and are now rapidly separating. The distance between them was much greater than is apparent on the diagram, for the plane of the comet's orbit is tilted at an angle of about 44° with the plane of the orbit of the Earth. If the reader will imagine the line of the comet's path to be lifted up a little over an inch from the paper he will have an approximate idea of the true relative position of the two orbits. The diagram was drawn from the elements by Mr. H. R. Morgan which are given below.

Elements of Comet *a* 1906 (Brooks).

$T = 1905$ Dec. 21.986600 G. M. T.

$\pi = 15° 47' 1''.$ }
$\Omega = 286 17 53 .$ } 1906.0
$i = 126 29 0 .$ }

$q = 1.29468$

$\cos \beta \Delta\lambda = +3''.2$
$\Delta\beta = +0 .4$

CONSTANTS TO EQUATOR

$x = r\,[9.803431] \sin (243° 18' 08'' + v)$
$y = r\,[9.999809] \sin (331 14 20 .4 + v)$
$z = r\,[9.887780] \sin (59 50 30 .7 + v)$

Computed from observations made at Glasgow Jan. 27, 30, and Feb. 2.

HERBERT R. MORGAN.

New Comet Brooks (*a* 1906).—I discovered a new comet this morning, January 26—15 hours, in R. A. $16^h 19^m 30^s + 47° 10'$, with moderate motion northwest. The comet is bright telescopic, large and diffuse with considerable central condensation, and a smudge of a tail.

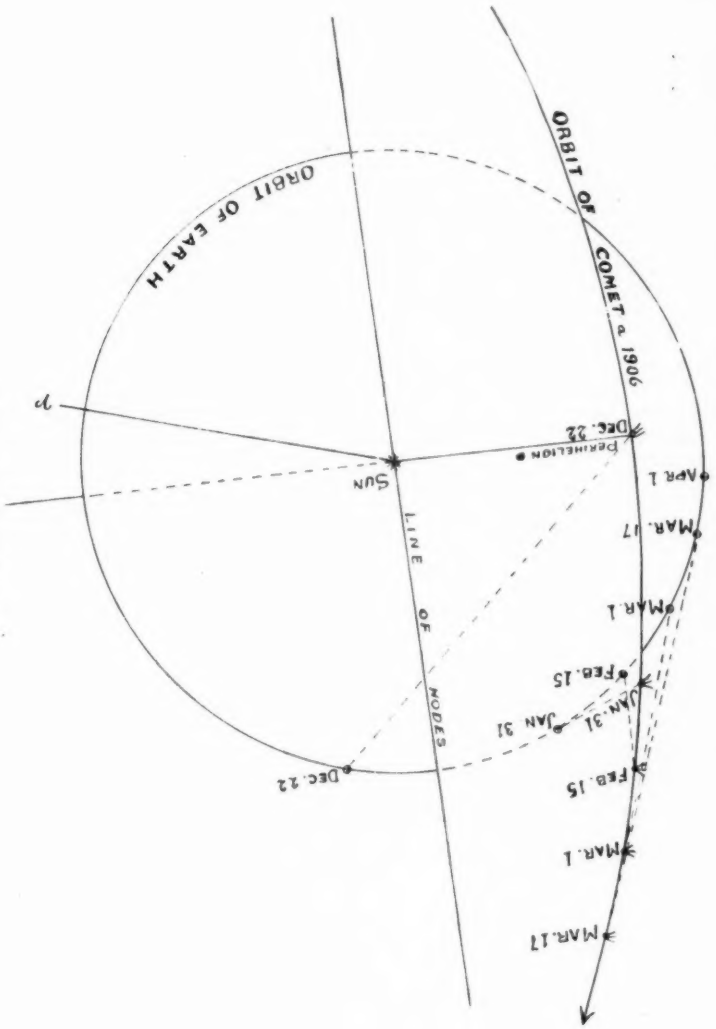
WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.
January 27, 1906.

Comet *a* 1906.—The following elements and ephemeris of comet *a* 1906 (Brooks) have been computed by Messrs. Crawford, and Champreux from observations of January 28, 29, 30.

ELEMENTS.

Time of passing perihelion	$= T =$ Dec. $19^d.47.1905$, G. M. T.
Perihelion minus node	$= \omega = 86° 22'$
Longitude of node	$= \Omega = 285° 27'$
Inclination	$= i = 126° 49'$
Perihelion distance	$= q = 1.2826$



ORBIT OF COMET *a* 1906

EPHEMERIS.

G. M. T.	R. A.	Dec.	Light.
	d h m s	° ′	
1906 Jan.	31.5 11 15 8	+55 3	1.04
Feb.	4.5 16 7 12	+62 36	
"	8.5 15 50 24	+70 37	
Feb.	12.5 15 5 52	+78 37	1.05

Astronomical Bulletin, No. 221.
Harvard College Observatory,
January 31, 1906.

Comet *a* 1906.—The following elements and ephemeris of comet *a* (Brooks) have been communicated by Rear Admiral C. M. Chester, U. S. N. Superintendent Naval Observatory. They were deduced by Miss Eleanor A. Lamson, from observations on January 27, 28, 29.

ELEMENTS.

Time of passing perihelion $= T =$ Dec. $24^d.49941$ 1905, G. M. T.
Longitude of perihelion $= \pi = 19° 53' 16''$.
Longitude of node $= \Omega = 287\ 16\ 20$.
Inclination $= i = 126\ 4\ 30$.
Perihelion distance $= q = 1.3050$
Residuals (O—C): $\cos\beta\Delta\lambda = -3''$, $\Delta\beta = -1''$.

HELIOCENTRIC COÖRDINATES.

$x = r\,[9.803366] \sin(244° 46' 47'' + v)$
$y = r\,[9.999957] \sin(333\ 47\ 34 + v)$
$z = r\,[9.887579] \sin(\ 63\ 7\ 25 + v)$

EPHEMERIS.

G. M. T.	R. A.	Dec.	Light
	d h m s	° ′	
1906 Feb.	4.5 16 7 2	+62 42.1	1.00
"	8.5 15 49 28	+70 55.0	
"	12.5 15 0 30	+79 8.4	
Feb.	16.5 11 29 34	−84 48.0	0.94

Astronomical Bulletin, No. 222.
Harvard College Observatory.
February 3, 1906.

Comet *a* 1906.—The following ephemeris of comet *a* 1906 (Brooks) was computed by Messrs. Crawford and Champreux from elements derived from observations of January 28, February 1, and February 6.

EPHEMERIS.

G. M. T.	R. A.	Dec.	Light.
	h m s	° ′	
1906 Feb. 12.5	15 3 12	+78 55	1.10
" 16.5	11 47 28	+84 43	
" 20.5	7 22 0	+81 18	
Feb. 24.5	6 17 4	+74 35	0.78

Astronomical Bulletin,
Harvard College Observatory,
February 10, 1906.

Elements and Ephemeris of Comet *a* 1906 (Brooks.)—The following observations, by Mr. J. D. Maddrill, were kindly forwarded by the Director

of the Lick Observatory.

1906	Mt. H. M. T.			Comet's Apparent α			δ		
Jan. 27	17h	29m	27s	16h	18m	41s.41	+49°	08′	30″.5
Feb. 1	10	30	46	16	13	09 .52	+57	23	46 .5
Feb. 6	8	48	03	15	59	30 .99	+67	05	08 .0

The results derived therefrom are as follows:

ELEMENTS.

$T = 1905$ December 22.29263 Gr. M. T.
$\omega = 89° 51′ 53″.7$
$\Omega = 286 24 22 .1$ 1906.0
$i = 126 26 07 .3$
$q = 1.296318$

O − C	I	III
cos δ Δα	+1″.0	+1″.0
Δα	+0 .5	+2 .5

CONSTANTS FOR THE EQUATOR 1906.0.

$x = r\,[9.803389] \sin (243° 29′ 42″.3 + v)$
$y = r\,[9.999830] \sin (331 33 15 .1 + v)$
$z = r\,[9.887772] \sin (\ 60 14 19 .5 + v)$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1906	True α h	m	s	True δ °	′	″	Log Δ	Br.
Feb. 12.5	15	03	12.8	+78	54	42	9.9602	1.10
16.5	11	47	28.0	84	43	27	9.9682	
20.5	7	21	58.9	81	17	42	9.9850	
24.5	6	17	04.5	74	34	42	0.0089	0.78
Feb. 28.5	5	55	48.5	68	10	14	0.0377	
Mar. 4.5		46	40.6	62	29	01	0.0694	
8.5		42	28.5	57	32	42	0.1022	0.44
12.6		40	45.1	53	17	22	0.1352	
16.5		40	27.3	49	37	36	0.1675	
Mar. 20.5	5	41	04.0	+46	27	57	0.1987	0.25

Brightness January 28, 1906 = 1.00

R. T. CRAWFORD,
A. J. CHAMPREUX.

Lick Observatory Bulletin No. 91.

Elements of Comet *c* 1905.—In *A. N.* 4067 Mr. A. Wedemeyer gives elements of this comet depending upon three normal places on the dates December 8, 17 and 31. The normals are very closely represented by the elements.

$T = 1906$ Jan. 22.40219 Berlin M. T.
$\omega = 199° 15′ 27″.7$
$\Omega = 92 04 31 .3$ 1906.0
$i = 43 39 15 .7$
$\log q = 9.333345$

Ephemeris of Comet *c* 1905 (Giacobini)—The ephemeris here given is an extension of that published by Dr. Crawford in Bulletin Number 88.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1906	True α h	m	s	True δ °	′	″	Log Δ	Br.
Feb. 11.5	23	56	46.5	−19	04	16	0.0812	6.2
12.5	0	04	59.2	18	18	12		
13.5		12	54.4	17	31	42		

1906		True α			True δ			Log Δ	Br.
		h	m	s	°	′	″		
Feb.	14.5	0	20	32.7	−16	45	00		
	15.5		27	54.9	15	58	14	0.0986	4.3
	16.5		35	01.4	15	11	36		
	17.5		41	52.9	14	25	16		
	18.5		48	29.8	13	39	21		
	19.5	0	54	53.0	12	53	57	0.1197	3.1
	20.5	1	01	03.1	12	09	10		
	21.5		07	00.5	11	25	05		
	22.5		12	45.8	10	41	46		
	23.5		18	19.7	9	59	15	0.1433	2.3
	24.5		23	42.7	9	17	35		
	25.5		28	55.3	8	36	47		
	26.5		33	57.9	7	56	54		
	27.5		28	51.1	7	17	55	0.1680	1.7
Feb.	28.5		43	35.4	6	39	53		
Mar.	1.5		48	11.1	6	02	44		
	2.5		52	38.7	5	26	30		
	3.5	1	56	58.4	4	51	13	0.1933	1.3
	4.5	2	01	10.9	4	16	48		
	5.5		05	16.4	3	43	17		
	6.5		09	15.3	3	10	38		
Mar.	7.5	2	13	07.8	− 2	38	52	0.2184	1.0

Brightness December 6, 1905 = 1.00

E. SMITH,
S. EINARSON.

Lick Observatory, Bulletin No. 91.

Circular Elements and Ephemeris of 1905 SF (Tauntonia). This asteroid was discovered by J. H. Metcalf, Taunton Mass., by photography, December 5, 1905, and two photographic positions on December 5 and December 29 were used for the circular elements. Its magnitude is about 12. If observations are secured, I should be glad of them. A similar set of elements was derived by Miss E. A. Lamson, using positions on December 5, and December 17.

ELEMENTS:

Epoch. 1905 Dec. 5.55327 Gr. M. T.

$u = 342° 13' 12''$
$\Omega = 87 15 56$ } 1906.0
$i = 11 6 8$ }
$\mu = 704''.047$
$\log a = 0.46827$

CONSTANTS TO THE EQUATOR.

$x = [0.46009] \sin (159° 26' 0'' + \mu t)$
$y = [0.43063] \sin (74 19 31 + \mu t)$
$z = [0.11457] \sin (46 3 25 + \mu t)$

EPHEMERIS.

G. M. T.		α			δ	
		h	m	s	°	′
1906. Mar.	1.5	4	19	21	+21	14.4
	5.5	4	22	51	21	32.2
	9.5	4	26	37	21	49.9
	13.5	4	30	38	22	7.5
	17.5	4	34	52	22	24.8
	21.5	4	39	20	22	41.8
	25.5	4	44	0	22	58.4
	29.5	4	48	52	+23	14.6

HERBERT A. MORGAN.

New Asteroids.—Dr. Max Wolf's powerful 16-inch cameras at Königstuhl, near Heidelberg, Germany continue to add to the number of new minor planets with wonderful rapidity. Those discovered the first month of this year extend the provisional numbering from S H to S X.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Feb. 1, 1906.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	h	R. A. 1900. m	Decl. 1900. ° ′	Magn.	Name.	h	R. A. 1900. m	Decl. 1900. ° ′	Magn.
X Androm.	0	10.8	+46 27	12.0*d*	RS Tauri	5	46.1	+15 51	10.5
T "		17.2	+26 26	12.3*d*	Z "		46.7	+15 46	<13
T Cassiop.		17.8	+55 14	9.4 *i*	RU "		47.3	+15 42	11.5
R Androm.		18.8	+38 1	11.5 *i*	V Camelop.		49.4	+74 30	13.3
S Ceti		19.0	− 9 53	12.5 *i*	U Orionis		49.9	+20 10	10.8 *i*
Y Cephei		31.3	+79 48	10.3 *i*	X Aurigae	6	4.4	+50 14	9.5
U Cassiop.		40.8	+47 43	9.8*d*	V Aurigae		16.5	+47 45	11 *i*
V Androm.		44.6	+35 6	9.5 *i*	V Monoc.		17.7	− 2 9	8.6*d*
RR "		45.9	+33 50	12.7*d*	R "		33.7	+ 8 49	<12
W Cassiop.		49.0	+58 1	12.3	δ Lyncis.		35.9	+58 0	11.0*d*
U Androm.	1	9.8	+40 11	13.0	Nova Gem.		37.8	+30 3	<13.5
S Cassiop.		12.3	+72 5	14.5	X "		40.7	+30 23	13.0*d*
S Piscium		12.4	+ 8 24	13.0*d*	W Monoc.		47.5	− 7 2	13.5*d*
U "		17.7	+12 21	11.5*d*	Y "		51.3	+11 22	13.7*d*
R "		25.5	+ 2 22	13.5*d*	X "		52.4	− 8 56	8.1
RU Androm		32.8	+38 10	11.0*d*	R Lyncis		53.0	+55 28	10.0*d*
Y "		33.7	+38 50	12.0 *i*	RS Gemin.		55.2	+30 40	<12
X Cassiop.		49.8	+58 46	12.0*d*	R Gemin.	7	1.3	+22 52	12.3*d*
U Persei		52.9	+54 20	10.9*d*	V Can. Min.		1.5	+ 9 1	13.5*d*
S Arietis		59.3	+12 3	14.0*d*	R " "		3.0	+10 11	9.9 *i*
R "	2	10.4	+24 35	8.8*d*	RR Monoc.		12.4	+ 1 17	10.5 *i*
W Androm.		11.2	+43 50	13.6*d*	V Gemin.		17.6	+13 7	13.0*d*
Z Cephei		13.0	+81 12.6	13.5	S Can. Min.		27.3	+ 8 32	8.7*d*
o Ceti		14.3	− 3 26	4.6*d*	Z Puppis		28.3	−20 27	<12
S Persei		15.7	+58 8	8.8 *i*	T Can. Min.		28.4	+11 58	10.5 *i*
R Ceti		20.9	− 0 38	10.0*d*	X Puppis.		28.4	−20 42	9.5
U "		28.9	−13 35	10.6 *i*	U Can. Min.		35.9	+ 8 37	10 *d*
RR Cephei		29.4	+80 42	13	S Gemin.		37.0	+23 41	10.3*d*
R Triang.		31.0	+33 50	6.1	T "		43.3	+23 59	14.0*d*
T Arietis		42.8	+17 6	10.0	U "		49.2	+22 16	11.0 *i*
W Persei		43.2	+56 34	10.0*d*	U Puppis		56.1	−12 34	<12
U Arietis	3	5.5	+14 25	8.6*d*	R Cancri	8	11.0	+12 2	9.8*d*
X Ceti		14.3	− 1 26	13.0*d*	V "		16.0	+17 36	12.5*d*
Y Persei		20.9	+43 50	8.9 *i*	RT Hydrae		24.7	− 5 59	9.8
R "		23.7	+35 20	8.8*d*	U Cancri		30.0	+19 14	13.5*d*
Nova Per. No. 2		24.4	+43 34	12.7*d*	X Urs. Maj.		33.9	+50 29	1.3
S Fornacis		41.9	−24 42	8.0	S Hydrae		48.4	+ 3 27	8.4*d*
U Eridani		46.2	−25 16	9.5	T "		50.8	− 8 46	12.0*d*
T "		51.0	−24 20	<12	T Cancri		51.0	+20 14	8.0 *i*
W "	4	7.3	−25 24	<12	S Pyxidis	9	0.7	−24 41	<12
T Tauri		16.2	+19 18	12.5*d*	W Cancri		4.0	+25 39	12 *d*
W "		22.2	+15 49	8.4	X Hydrae		30.7	−14 15	12
R "		22.8	+ 9 56	12.5*d*	Y Draco.		31.1	+78 18	13.5*d*
S "		23.7	+ 9 44	11.0 *i*	R Leo. Min.		39.6	+34 58	9.1*d*
T Camelop.		30.4	+65 57	9.0*d*	RR Hydrae		40.4	−23 34	9.5
X Camelop		32.6	+74 56	10.8	R Leonis		42.2	+11 54	8.5 *i*
V Tauri		46.2	+17 22	14.0*d*	Y Hydrae		46.4	−22 33	8.0
R Orionis		53.6	+ 7 59	11.5*d*	V Leonis		54.5	+21 44	10.0 *i*
R Leporis		55.0	+14 57	9.7	R Urs. Maj.	10	37.6	+69 18	8.8 *i*
T "	5	0.6	−22 2	10.5*d*	V Hydrae		46.8	−20 43	9.7
V Orionis		0.8	+ 3 58	13.2*d*	W Leonis		48.4	+14 15	<13
R Aurigae		9.2	+53 28	13.5*d*	S "	11	5.7	+ 6 0	10.0
W "		20.1	+36 49	13.7*d*	R Comae		59.1	+19 20	14.0
S Orionis		24.1	− 4 46	13.2	RX Virginis		59.6	− 5 13	8.5
S Camelop.		30.2	+68 45	9.0*d*	RW "	12	2.1	− 6 12	7.3
T Orionis		30.9	− 5 32	10.8*d*	T "		9.5	− 5 29	10.2
U Aurigae		35.6	+31 59	13.7*d*	R Corvi		14.4	−18 42	10.6

Approximate Magnitudes of Variable Stars on Feb. 1, 1906.—

(Continued.)

Name.	R. A. 1900. h m	Decl 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn.
T Can. Ven.	12 25.2	+32 3	9.0	R Draco.	16 32.4	+66 58	9.3 *i*
Y Virginis	28.7	− 3 52	12.0	RV Herc.	56.8	+31 22	10.0 *i*
T Urs. Maj.	31.8	+60 2		T "	18 5.3	+31 0	8.8 *i*
R Virginis	33.4	+ 7 32	8.0 *i*	RW Lyrae	42 2	+43 32	10.5 *i*
RS Urs Maj.	34.4	+59 3	9.2 *i*	RT "	57.8	+37 22	10.3 *i*
S " "	39.6	+61 38	8.4 *i*	V "	19 5.2	+29 30	9.5 *i*
RU Virginis	42.2	+ 4 42	9.0	U Draco.	9.9	+67 7	<12.5
U "	46.0	+ 6 6	8.5	TY Cygni	29.8	+28 6	<12 *i*
RT "	57.6	+ 5 43	9.0	R Cygni	34.1	+49 58	7.0 *i*
RV "	13 2.7	−12 38	<12	RT Cygni	40.8	+48 32	10.5*d*
V "	22.6	− 2 39	9.5	X Cygni	46.7	+32 40	5.5*d*
R Hydrae	24.2	−22 46	8.0 *i*	Z Cygni	58.6	+49 46	10.5*d*
S Virginis	27.8	− 6 41	8.7	S "	20 3.4	+57 42	11.5 *i*
T Urs. Min.	32.6	+73 57	12.5 *i*	RS Cygni	9.8	+38 28	7.0 *i*
R Can. Ven.	44.6	+40 2	8.5 *i*	R Delph.	10.1	+ 8 47	8.0 *i*
RR Virginis	59.6	− 8 43	11.0	WX Cygni	14.8	+37 8	12.0*d*
Z Bootis	14 1.7	−13 58	8.0	U "	16.5	+47 35	8.5*d*
Z Virginis	5.0	−12 50	<12	RW "	25.2	+39 39	10.5*d*
S Bootis	19.5	+54 16	12.5 *i*	ST Cygni	29.9	+54 38	12.6*d*
RS Virginis	22.3	+ 5 8	9.5*d*	V "	38.1	+47 47	13.0
R Camelop.	25.1	+84 17	8.5 *i*	RZ "	48.5	+46 59	12.0 *i*
V Bootis	25.7	+39 18	9.2*d*	UX "	50.9	+30 2	12.5*d*
R Bootis	32.8	+27 10	8.1 *i*	X Cephei	21 3.6	+82 40	<13
V Librae	34.8	−17 14	10.0	T "	8.2	+68 5	7.5 *i*
U Bootis	49.7	+18 6	12.0	S "	36.5	+78 10	11.5*d*
RT Librae	15 0.8	−18 21	<12	RU Cygni	37.3	+53 52	9.5*d*
T "	5.0	−19 38	<12	SS "	38.8	+43 8	12.0
Y "	6.4	− 5 38	<12	RT Pegasi	59.8	+34 38	11.5*d*
S "	15.6	−20 2	9.0 *i*	T "	22 4.0	+12 3	10.5*d*
S Serpentis	17.0	+14 40	<12	Y "	6.8	+13 52	<12
S Coronae	17.3	+31 44	9.5 *i*	RS "	7.4	+14 4	11.5
RS Librae	18.5	−22 33	10.0*d*	T Lacertae	17.9	+33 52	9.8
RU "	27.7	−14 59	<12	S "	24.6	+39 48	12.1*d*
W "	32.2	−15 51	<12	R "	38.8	+41 51	9.0 *i*
S Urs. Min.	33.4	+78 38	10.5*d*	S Aquarii	51.8	−20 53	9.2*d*
R Coronae	44.4	+28 28	5.9	R Pegasi	23 1.6	+10 0	11.2*d*
— "	45.3	+37 49	8.8 *i*	V Cassiop.	7.4	+59 8	11.8*d*
V "	46.0	+39 52	9.5 *i*	W Pegasi	14.8	+25 24	8.0
R Serpentis	46.1	+15 26	<12	S "	15.5	+ 8 22	11.3*d*
RR Herc.	16 1.5	+50 46	8.5	R Aquarii	38.6	−15 50	8.5 *i*
R "	1.7	+18 38	<12	Z Cassiop.	39.7	+56 2	13.0*d*
U Serpentis	2.5	+10 12	<12	Z Aquarii	47.1	−16 25	9.3*d*
RU Herc.	6.0	+25 20	9.0	RR Cassiop.	50.6	+53 10	12.0*d*
W Coronae	11.8	+38 3	8.2 *i*	"	53.3	+50 50	12.7
U Herculis	21.4	+19 7	9.0 *i*	"	58.2	+55 7	10.0 *i*
W "	31.7	+37 32	<12				

The letter *i* denotes that the light is increasing, the letter *d* that the light is decreasing, the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled by Mr. Leon Campbell of the the Harvard College Observatory, from observations made at the Leander McCormick, Whiteside and Harvard Observatories.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

U Cephei.

	d	h
Apr.	1	10
	4	22
	7	10
	9	22
	12	10
	14	21
	17	9
	19	21
	22	9
	24	21
	27	9
	29	20

Z Persei

Apr.	1	15
	4	17
	7	18
	10	20
	13	21
	16	22
	20	0
	23	1
	26	2
	29	4

Algol.

Apr.	2	21
	5	18
	8	15
	11	11
	14	8
	17	5
	20	2
	22	23
	25	20
	28	16

RT Persei

Apr.	1	17
	2	14
	3	10
	4	6
	5	3
	5	23
	6	20
	7	16
	8	12
	9	9
	10	5
	11	1
	11	22
	12	18
	13	15
	14	11
	15	7
	16	4
	17	0
	17	21
	18	17
	19	13

RT Persei

Apr.	20	10
	21	6
	22	3
	22	23
	23	19
	24	16
	25	12
	26	8
	27	5
	28	1
	28	22
	29	18
	30	14

λ Tauri

Apr.	3	19
	7	18
	11	17
	15	15
	19	14
	23	13
	27	12

R Canis Maj.

Apr.	1	20
	2	23
	4	2
	5	6
	6	9
	7	12
	8	15
	9	19
	10	22
	12	1
	13	4
	14	8
	15	11
	16	14
	17	17
	18	21
	20	0
	21	3
	22	6
	23	10
	24	13
	25	16
	26	20
	27	23
	29	2
	30	5

Y Camelop.

Apr.	3	17
	7	0
	10	7
	13	15
	16	22
	20	5
	23	13
	26	20
	30	3

RR Puppis

Apr.	3	13
	10	0
	16	10
	22	20
	29	7

V Puppis.

Apr.	2	7
	3	18
	5	5
	6	16
	8	2
	9	13
	11	0
	12	11
	13	22
	15	9
	16	20
	18	7
	19	18
	21	5
	22	16
	24	2
	25	13
	27	0
	28	11
	29	22

S Cancri.

Apr.	3	15
	13	3
	22	14

S Antliæ.

Apr.	1	10
	2	9
	3	8
	4	8
	5	7
	6	6
	7	6
	8	5
	9	4
	10	4
	11	3
	12	2
	13	2
	14	1
	15	0
	16	0
	16	23
	17	22
	18	22
	19	21
	20	20
	21	20
	22	19
	23	18
	24	18
	25	17
	26	16

S Antliæ.

Apr.	27	16
	28	15
	29	14
	30	14

S Velorum.

Apr.	4	14
	10	12
	16	11
	22	9
	28	8

W Urs. Maj.

Period 4^h

Apr. 1-30 15^h

RR Velorum

Apr.	1	10
	3	7
	5	3
	7	0
	8	20
	10	17
	12	13
	14	0
	16	6
	18	3
	19	23
	21	20
	23	16
	25	13
	27	9
	29	6

Z Draconis.

Apr.	1	17
	3	2
	4	10
	5	19
	7	4
	8	12
	9	21
	11	5
	12	14
	13	22
	15	7
	16	16
	18	0
	19	9
	20	17
	22	2
	23	10
	24	19
	26	4
	27	12
	28	21
	30	5

δ Libræ

Apr.	2	23
	5	7
	7	14

δ Libræ

Apr	9	22
	12	6
	14	14
	16	22
	19	6
	21	14
	23	21
	26	5
	28	13
	30	21

U Coronæ

Apr.	2	18
	6	5
	9	16
	13	3
	16	14
	20	0
	23	11
	26	22
	30	9

R Aræ

Apr.	3	6
	7	16
	12	2
	16	12
	20	22
	25	9
	29	13

U Ophiuchi.

Apr.	1	3
	1	23
	2	19
	3	15
	4	11
	5	7
	6	4
	7	0
	7	20
	8	16
	9	12
	10	8
	11	4
	12	0
	12	20
	13	17
	14	13
	15	9
	16	5
	17	1
	17	21
	18	17
	19	14
	20	10
	21	6
	22	2
	22	22
	23	18
	24	14

Minima of Variable Stars of the Algol Type.—Continued.

U Ophiuchi.

	d	h
Apr.	25	10
	26	7
	27	3
	27	23
	28	19
	29	15
	30	11

Z Herculis.

	d	h
Apr.	1	17
	3	14
	5	17
	7	14
	9	17
	11	14
	13	16
	15	13
	17	16
	19	13
	21	16
	23	13
	25	16
	27	13
	29	16

RS Sagittarii.

	d	h
Apr.	2	12
	4	22
	7	8
	9	18
	12	4
	14	14
	17	0
	19	10
	21	20
	24	6
	26	16
	29	2

V Serpentis.

	d	h
Apr.	2	8
	5	19
	9	6
	12	17
	16	4
	19	14
	23	1
	26	12
	29	23

RX Herculis.

	d	h
Apr.	1	21
	2	18
	3	16
	4	13
	5	10
	6	8
	7	5
	8	2
	9	0
	9	21
	10	18
	11	16
	12	13
	13	10
	14	8
	15	5
	16	2
	17	0
	17	21
	18	18
	19	16
	20	13
	21	10
	22	8
	23	5
	24	2
	25	0
	25	21

RX Herculis.

	d	h
Apr.	26	18
	27	16
	28	13
	29	10
	30	8

RU Lyræ

	d	h
Apr.	1	21
	5	11
	9	2
	12	16
	16	7
	19	21
	23	11
	27	2
	30	16

U Sagittarii.

	d	h
Apr.	1	20
	5	6
	8	15
	12	0
	15	9
	18	18
	22	3
	25	12
	28	21

SY Cygni.

	d	h
Apr.	4	11
	10	11
	16	12
	22	12
	28	12

WW Cygni.

	d	h
Apr.	2	4
	5	12
	8	19
	12	3
	15	11

WW Cygni.

	d	h
Apr.	18	18
	22	2
	25	10
	28	17

SW Cygni

	d	h
Apr.	1	3
	5	17
	10	7
	14	21
	19	10
	24	0
	28	14

VW Cygni.

	d	h
Apr.	8	22
	17	8
	25	19

UW Cygni

	d	h
Apr.	1	4
	4	15
	8	1
	11	12
	14	23
	18	10
	21	21
	25	7
	28	18

W Delphini

	d	h
Apr.	2	19
	7	14
	12	9
	17	5
	22	0
	26	19

Y Cygni

	d	h
Apr.	1	7
	2	20
	4	7
	5	20

Y Cygni

	d	h
Apr.	7	7
	8	20
	10	7
	11	19
	13	7
	14	19
	16	7
	17	19
	19	7
	20	19
	22	7
	23	19
	25	6
	26	19
	28	6
	29	19

VV Cygni

	d	h
Apr.	2	2
	3	13
	5	1
	6	12
	8	0
	9	11
	19	22
	12	10
	13	21
	15	9
	16	20
	18	8
	19	19
	21	7
	22	18
	24	5
	25	17
	27	4
	28	16
	30	3

UZ Cygni

	d	h
Apr.	7	21

Variable Stars of Short Period not of the Algol Type.

The times of maxima only are given; the times of minima may be obtained by subtracting the interval printed in parentheses under the name of the star.

Y Aurigæ

	d	h
	(−0	18)
Apr.	2	5
	6	1
	9	22
	13	18
	17	15
	21	12
	25	8
	29	5

T Monocerotis

	d	h
	(−7	22)
Apr.	4	2
May.	1	3

W Geminorum

	d	h
	(−2	16)
Apr.	6	17
	14	11
	22	5
	29	23

ζ Geminorum

	d	h
	(−3	0)
Apr.	10	16
	20	19
	30	23

V Carinæ

	d	h
	(−2	4)
Apr.	2	3

V Carinæ

	d	h
Apr.	8	19
	15	12
	22	5
	28	21

T Velorum

	d	h
	(−1	9)
Apr.	4	6
	8	22
	13	13
	18	4
	22	19
	27	11

W Carinæ

	d	h
	(−1	0)
Apr.	2	6
	6	15
	11	0
	15	9
	19	18
	24	2
	28	11

S Muscæ

	d	h
	(−3	11)
Apr.	7	6
	16	21
	26	13

T Crucis

	d	h
	(−2	1)
Apr.	2	19
	9	13
	16	6
	23	0
	29	18

R Crucis

	d	h
	(−1	9)
Apr.	3	22
	9	18
	15	13
	21	9
	27	5

Variable Stars of Short Period not of the Algol Type.—Continued.

S Crucis

	d	h
	(−1	12)
Apr.	5	5
	9	21
	14	14
	19	7
	23	23
	28	16

W Virginis

	d	h
	(−8	4)
Apr.	1	8
	18	15

V Centauri

	d	h
	(−1	12)
Apr.	4	12
	10	0
	15	12
	21	0
	26	12

R Triang. Austr.

	d	h
	(−1	10)
Apr.	1	19
	5	4
	8	13
	11	23
	15	8
	18	17
	22	3
	25	12
	28	21

S Triang. Austr.

	d	h
	(−6	0)
Apr.	5	1
	11	9
	17	17
	24	0
	30	8

S Normae

	d	h
	(−4	9)
Apr.	10	13
	20	7
	30	1

R V Scorpii

	d	h
	(−1	10)
Apr.	4	10
	10	12
	16	13
	22	15
	28	16

X Sagittarii

	d	h
	(−2	21)
Apr.	4	18
	11	18
	18	19
	25	19

Y Ophiuchi

	d	h
	(−6	5)
Apr.	4	23
	22	2

W Sagittarii

	d	h
	(−3	0)
Apr.	8	14
	16	4
	23	18

Y Sagittarii

	d	h
	(−2	2)
Apr.	4	6
	10	1
	15	19
	21	14
	27	8

U Sagittarii

	d	h
	(−3	0)
Apr.	1	13
	8	7

U Sagittarii

	d	h
Apr.	15	1
	21	19
	28	13

β Lyræ

	(−3	2)
	(−3	7)
Apr.	4	8
	11	0
	17	6
	23	22
	30	4
May	6	20

κ Pavonis

	d	h
	(−4	9)
Apr.	1	8
	10	10
	19	13
	28	15

U Aquilæ

	d	h
	(−2	5)
Apr.	5	13
	12	13
	19	14
	26	15

U Vulpeculae

	d	h
	(−2	3)
Apr.	3	13
	11	12
	19	12
	27	11

SU Cygni

	d	h
	(−1	8)
Apr.	1	13
	5	9
	9	5
	13	2
	16	22

SU Cygni

	d	h
Apr.	20	18
	24	15
	28	11

η Aquilae

	d	h
	(−2	9)
Apr.	2	2
	9	6
	16	10
	23	14
	30	19

S Sagittae

	d	h
	(−3	10)
Apr.	6	23
	15	8
	23	17

X Cygni

	d	h
	(−6	5)
Apr.	1	5
	17	14

T Vulpeculae

	d	h
	(−1	10)
Apr.	4	13
	9	0
	13	10
	17	21
	22	7
	26	18

WZ Cygni Minimum

	d	h
Apr.	1	11
	2	15
	3	19
	4	23
	6	3
	7	7
	8	11

WZ Cygni Minimum

	d	h
Apr.	9	15
	10	19
	11	23
	13	4
	14	8
	15	12
	16	16
	17	20
	19	0
	20	4
	21	8
	22	12
	23	16
	24	20
	26	0
	27	4
	28	8
	29	12
	30	16

TX Cygni

	d	h
	(−5	3)
Apr.	7	0
	21	17

VY Cygni

	d	h
	(−2	2)
Apr.	4	21
	12	17
	20	14
	28	10

δ Cephei

	d	h
	(−1	9)
Apr.	3	0
	8	9
	13	18
	19	3
	24	11
	29	20

Nomenclature of Newly Discovered Variable Stars.*

Provis. Notation A. N.	Name	Position for 1900.0 R. A. h	m	s	Decl. °	′	Prec. 1900 R. A. s	Decl. ′
189.1904	RW Andromedae	0	41	56	+32	8.4	+3.23	+0 33
41.1905	RV Cassiopeiae	0	47	6	46	52.8	3.36	0.33
38.1905	RX Andromedae	0	58	58	40	46.2	3.36	0.32
186.1904	RU Cassiopeiae	1	5	10	64	29.2	3.86	0.32
46.1905	RW Cassiopeiae	1	30	42	57	14.8	3.87	0.31
187.1904	RU Persei	3	23	57	39	18.9	3.92	0.21
102.1905	RW Tauri	3	57	45	27	51.0	3.68	0.17
61.1905	RV Persei	4	4	9	33	59.4	3.86	0.16
45.1905	RV Tauri	4	40	58	25	59.9	3.69	0.11
79.1905	RS Cephei	4	48	34	80	5.8	10.36	0.10
40.1905	RR Camelopardalis	5	23	24	72	22.8	7.23	0 05
62.1905	RU Aurigae	5	33	24	+37	35	4.09	0.04
49.1903	Y Orionis	5	36	36	− 4	11.3	2.98	+0.03
47.1905	RT Aurigae	6	22	9	+30	33.3	3.86	−0.03
43.1905	RU Monocerotis	6	49	24	− 7	28.2	2.90	0.07

* From No. 4061 of the *Astronomische Nachrichten.*

Provis. Notation A. N.	Name	Position for 1900.0 R. A. h	m	s	Decl. °	′	Prec. 1900 R. A. s	Decl. ′
42.1905	RT Monocerotis	8	3	58	−10	30.4	2.86	0.17
105.1905	RS Camelopardalis	8	36	56	+79	19.7	8.57.	0.21
78.1905	SS Virginis	12	20	7	+ 1	19.4	3.07	0.33
67.1905	RS Ursae majoris	12	34	23	+59	2.6	2.74	0.33
—	T Muscae	13	13	30	−73	55.0	4.53	0.32
73.1905	RZ Virginis	13	16	45	+ 2	22.2	3.05	0.32
106.1905	RR Ursae majoris	13	22	28	+62	54.6	2.15	0.31
60.1905	RX Ophiuchi	16	47	52		5 33.8	2.95	−0.10
77.1905	RY Ophiuchi	18	11	38		3 39.5	2.99	+0.02
75.1905	RU Draconis	18	18	5		59 32.0	+0.81	0.03
74.1905	RT Draconis	18	21	21		72 39.6	−1.19	0.03
39.1905	RS Draconis	18	40	14		74 14.0	−1.59	0.06
188.1904	RR Draconis	18	40	54		62 34.5	+0.54	0.06
103.1905	RZ Ophiuchi	18	40	55		7 6.9	2.91	0.06
80.1905	SV Lyrae	18	42	1		36 11.7	2.11	0.06
59.1905	SU Lyrae	18	50	7		36 23.1	2.11	0.07
81.1905	SW Lyrae	18	51	8		29 43.5	2.33	0.07
82.1905	SX Lyrae	18	51	9		31 19.7	2.28	0.07
64.1903	SS Aquilae	19	27	49		10 18.7	2.85	0.12
33.1905	SU Aquilae	19	31	2		3 52.1	2.99	0.13
78.1903	ST Aquilae	19	44	35		12 7.1	2.81	0.15
107.1905	WZ Cygni	20	49	18		38 27.1	2.29	0.22
185.1904	RT Cephei	21	42.2			64 9	1.53	0.28
44.1905	RY Andromedae	23	15	53	+39	5.4	+2.86	+0.33

Nomenclature of Newly Discovered Variable Stars.—Continued.

Provis. Notation. A. N.	Name	Chart-Place R. A. h	m	s	Decl. °	′	Magnitude Max. m	Min. m	
189.1904	RW Andromedae	0	39	31	+31	53.6	8.3	<12	ph
41.1905	RV Cassiopeiae	0	44	35		46 38.1	9	<12½	ph
38.1905	RX Andromedae	0	56	26		40 31.6	10.5	11.8	ph
186.1904	RU Cassiopeiae	1	2	17		64 14 8	5.1	5.5	v
46.1905	RW Cassiopeiae	1	27	49		57 0.9	8.9	11.0	ph
187.1904	RU Persei	3	21	1		39 9.4	9.5	11	v
102.1905	RW Tauri	3	55	0		27 43.3	7.1	<11	ph
61.1905	RV Persei	4	1	15		33 52.0	9.5	11.0	ph
45.1905	RV Tauri	4	38	12		25 54.7	9.1	10.5	ph
79.1905	RS Cephei	4	40	51		80 1.0	9.5	12	ph
49.1905	RR Camelopardalis	5	17	59		72 20.2	9.5	10.5	ph
62.1905	RU Aurigae	5	30	20	+37	33	10.0	<12	ph
49.1905	Y Orionis	5	34	22	−	4 12.9	9.8	<15.2	ph
47.1905	RT Aurigae	6	19	15	+30	34.7	5.0	5.6	v
43.1905	RU Monocerotis	6	47	13	−	7 25.1	9.8	10.5	ph
42.1905	RT Monocerotis	8	1	49	−10	22.7	8.5	9.3	v
105.1905	RS Camelopardalis	8	30	26	+79	29.0	8.4	9.2	ph
78.1905	SS Virginis	12	17	49		1 34.4	8.3	12.5	ph
67.1905	RS Ursae majoris	12	32	19	+59	17.5	9	<12	ph
—	T Muscae	13	11	32	−73	47.1	8.0	9.7	ph
73.1905	RZ Virginis	13	14	8	+	2 36.5	9	12	v
106.1905	RR Ursae majoris	13	20	51		63 8.7	9.4	<12	ph
60.1905	RX Ophiuchi	16	45	40		5 38.5	9.8	<13	v
77.1905	RY Ophiuchi	18	9	24		3 38.8	8.5	<10.4	v
75.1905	RU Draconis	18	17	29		59 30.8	9.4	12.5	ph
74.1905	RT Draconis	18	22	14		72 38.2	9.4	12	ph
39.1905	RS Draconis	18	41	25		74 11.4	9.5	11.5	ph
188.1904	RR Draconis	18	40	30		62 31.9	8.5	<12	ph
103.1905	RZ Ophiuchi	18	38	45		7 4.3	9.0	10.5	ph
80.1905	SV Lyrae	18	40	26		36 8.9	10.5	13.5	ph
59.1905	SU Lyrae	18	48	31		36 19.9	10	<12.5	ph
81.1905	SW Lyrae	18	49	24		29 40.2	11	<13	ph

Provis. Notation. A. N.	Name	Chart-Place R. A. h	m	s	Decl. °	′	Magnitude Max. m	Min. m	
82.1905	SX Lyrae	18	49	27	31	16.4	11.5	<13	ph
64.1903	SS Aquilae	19	25	41	10	13.1	11	15	ph
33.1905	SU Aquilae	19	28	47	3	46.3	10	14	ph
78.1903	ST Aquilae	19	42	28	12	0 6	10.5	13.5	ph
107.1905	WZ Cygni	20	47	35	38	17.0	9.9	10.8	v
185.1904	RT Cephei	21	43.1		63	56	10	12½	ph
44.1905	RY Andromedae	23	13	44	+38	50.8	10	<12	ph

New Variable Star, 1.1906 Lyncis.—In *A. N.* 4070 Rev. Thos. D. Anderson of Northrig, Haddington, Scotland calls attention to the star BD. + 33°, 1686 (9.4m). He found the star, on Oct. 16 and 17, 1905, to be of magnitude 9.5; on Nov. 2, 9.7; and on Jan. 13, and 15, 1906, 10.8. The position of the star for 1855 is

R. A. $8^h\ 13^m\ 30.^s4$ Decl. $+\ 33°\ 58'.6$

Mr. M. Ebell from measurements of a photographic plate obtained at Potsdam 1894 Feb. 16, $8^h\ 36^m.0$, local sidereal time, finds the following positions for the variable and three comparison stars:

	BD °	R. A. 1900.0 h	m	s	Decl. 1900.0 °	′	Photo. Mag. m
Var.	+ 33 1686	8	16	21	+33	50.7	11.0
a	+ 33 1683	8	15	23	+33	42.0	9.8
b	+ 33 1687	8	17	04	+33	44.8	10.0
c	—	8	16	49	+33	55.0	11.0

Variable Star *Z* Camelopardalis.—In *A. N.* 4069 Mr. G. Van Biesbroeck gives a number of observations of this star, made during July and August 1905. He gives as a provisional formula for the maxima

1905 Aug. 18 (2417076) + 29.54 E.

Algol Variable *RW* Tauri.—Mr. Van Biesbroeck also gives a series of observations of RW Tauri (102.1905) at a minimum on the night of November 1. The observations began at $6^h\ 31^m$ and continued at intervals of three or four minutes until $9^h\ 30^m$ and thereafter at longer intervals until $12^h\ 36^m$ Greenwich M. T. The magnitude of the star at $6^h\ 31^m$ was 9.5, descended to 11.6 at $7^h\ 11^m$, remained nearly constant until $8^h\ 40^m$, reached 9.5 again at about $9^h\ 30^m$, and at $12^h\ 36^m$ had attained the brightness 8.0.

GENERAL NOTES.

Ancient Eclipses. English astronomers for recent months have been giving considerable attention to ancient eclipses as a reliable means of perfecting the lunar theory. We have received a carefully written letter from a prominent American astronomer expressing firm belief that no dependence whatever can be placed in the historic accounts we have concerning the dates of ancient eclipses for the purpose of aid in e lunar theory

Marcel Moye's Pamphlet on the Total Eclipse Aug. 30, 1905. We have been favored with a copy of Marcel Moye's pamphlet concerning the total eclipse of Aug. 30, 1905. The author of this interesting publication is a member of the Faculty of the University of Montpellier, France, and a member of the Flammarion Astronomical Society of Montpellier. He has written a careful and full account of this eclipse in French and compared it with others of which many good illustrations are given. Any one desiring a copy of this pamphlet can secure one by sending thirty cents to Professor Moye, 3 rue Achille-Bégé, Montpellier (Hérault,) France.

Astronomy in the Library of Congress. We have received from the Librarian of Congress, Class Q B: *Astronomy* (including Geodesy) of the classification of that Library. It is a pamphlet of eight pages of titles and sub-titles by number with plain cross-references to divisional letters. The plan for classification in regard to Astronomy is quite complete under most of the subdivisions.

Giant Sun and His Family.—Miss Mary Proctor has written a little volume on the "Giant Sun and His Family," which is the result of ten years' experience in lecturing on this and kindred themes. These lectures have generally been given before schools in New York City, and of course have been adapted to children of the higher grammar grades. While the book has been written so that young people may readily understand it, the themes are so presented that older people wishing to know about the Sun as a star, the total eclipses of the Sun, and especially the important one of August 30, 1905, about the planets and comets, meteors and shooting stars will find this popular account one entirely trustworthy, interesting and helpfully instructive. The illustrations are fresh, ample and well chosen. Miss Proctor is entertaining both in writing and in lectures.

The publishers are Silver, Burdett and Company, New York, Boston and Chicago.

The Detroit Observatory of the University of Michigan under the new Director W. J. Hussey is undergoing extensive repairs including a new addition. The improvements extend to the Observatory Library which connects directly with the residence. Mr. E. J. Madden has been appointed Instrument Maker at the Observatory, and has already begun his work of putting the instruments in condition for modern use. Mr. Madden was formerly employed at the Lick Observatory in this capacity, and later at the Solar Observatory at Pasadena. An instrument shop is being installed for his work.

To meet these expenses the University has appropriated $5000 already and very likely whatever more is needed will be forthcoming in due time. Professor Hussey has had fine opportunity for study and work in his chosen lines in Astronomy, and from the recent large responsibilities which he has been asked to bear he has shown a judgment and skill in his work that places him high in scientific rank.

POPULAR ASTRONOMY congratulates Professor Hussey as the new Director of Detroit Observatory.

Photographic Catalogue of the Heavens. The first volume of the photographic catalogue of the Heavens covering zone $+16°$ A $+18°$ from the Ob-

servatory at Bordeau has been received. It is a large quarto in form and contains about 320 pages. It covers three points; Introduction, a study of photographic images by G. Rayet; a photographic catalogue of the Pleiades by F. Kromm, and a table of the rectangular coördinates of the stars in the zone $+16^{\circ}$ to $+18^{\circ}$. We have given elsewhere a translation of part of the introduction.

The Great Star Arcturus. This brilliant star which is the leader in the constellation Boötis is placed next to Sirius in brightness by some, below Vega by others, and by another alternately above and below Capella. Its brightness was most impressive in 1858, October 5, when the Donati Comet swept over it. On that day its golden yellow light flashed through the comet very vividly when it was only twenty minutes of arc from the nucleus. It was remarked that the sight was rarely beautiful.

This star is so far away that its distance can not be known with any satisfactory degree of certainty. It has a proper motion of more than one second of arc, and on this account some astronomers think it may not be more than 25 light years distant from us; but others think the 50 or 60 light years would more safely measure the probable distance. From these facts it will be at once understood that such items as the following which sometimes appear in the news papers have no foundation at all in real knowledge in astronomy. The item furnished by a correspondent pertaining to the star Arcturus is as follows:—

There are other Suns in space that are infinitely larger than the one which gives us heat, light and life. The star Arcturus, which is known to be a Sun for a faraway system of planets, is 11,500,000 times farther removed from us than is our solar luminary. His diameter is 71,000,000 and his circumference about 224,000,000 miles. Our Sun is but 866,000 miles in diameter, a fact which proves that Arcturus is at least 551,000 times greater in bulk than is our "great orb of day."

Evidence of the Rotation of the Earth on its Axis. A correspondent in reading Darwin's Origin of Species comes upon this expression: "The belief in the revolution of the earth on its own axis was until lately, supported by hardly any direct evidence," and desires to know what the later evidence is that was probably referred to by Mr. Darwin.

In the first place the word revolution is not the proper one to use in this connection. Astronomers would say rotation of the earth on its axis. Revolution is applied to the motion of the earth around the Sun in its orbit.

Going back to the time of Copernicus, 1473-1543, we find that he offered the conjecture that the earth rotates on its own axis, because it was more reasonable to suppose such a motion, than it was to think that the great heavens themselves should revolve about the earth once every twenty-four hours. He had no proof, it was merely a reasonable conjecture.

In 1610 when Galileo turned his little telescope on the Sun and the planets and saw in the heavenly bodies the evidences of rotation, he then said Copernicus is right, the earth does rotate on its axis. Many readers of this will remember what severe trials it cost him to make public such a fact.

The evidence that convinced Galileo that the earth rotates on its axis was not definite proof, but only analogy. He reasoned, if the Sun and the planets generally rotate on their own axes it is more reasonable to believe, from analogy, that the earth likewise rotates on its axis.

But in 1851, when Foucault performed his classical experiment at the Pan-

théon in Paris, the rotation of the earth was demonstrated as a scientific fact. Those who could understand the relation of a pendulum, 200 feet long, as it made its slow vibrations, to that of the rotation of the earth on its axis could at once see that the proof was exact and complete. When this experiment was performed it was then easy to account for a multitude of other things that students and observers meet almost daily in the common walks of life, such as the deviations of projectiles, trade winds, ocean currents, motion of cyclones and other facts in meteorology.

The question that interests the physicist now is, whether or not the rotation of the earth on its axis is exactly uniform. All time reckoning is determined by the earth's rotation. If it is not uniform then our standard time must be erroneous.

We believe the rotation time of the earth is not uniform, but the error is so small that it can not yet be measured. Astronomers believe that for 1700 years the length of the day (which of course depends on the rotation of the earth on its axis) has not changed as much as one hundredth of a second, and yet they believe it is changing.

Depth of Definition in Photography. From the *British Journal of Photography*, p. 926, November number, we take the following interesting paragraph relating to the depth of definition in photography: "For the last half generation or so, we have been told, in season and out of season, and with remarkable emphasis, that depth of definition depends absolutely and only on focal length and aperture, and that the old idea to the contrary was altogether wrong; I venture to say that while the old idea was confused, curvature of field taking part in it in an uncertain way, the new notion is in error, being an attempt to force theoretical conditions that can never be realized into the position of practical facts. In the middle of the field, depth of definition does depend almost entirely upon focal length and aperture, though even here spherical aberration is not without effect, but a photograph is not made for the sake of a little patch in the middle of it. The characteristic necessity in a photographic lens is the power to define over a large field, and it is chiefly a practical recognition of this fact that has led to so much improvement in lenses during late years. At an angle, say, of thirty degrees from the axis the depth of definition may be almost at its maximum, as in the original double anastigmat of GOERZ, while in the same part of the field another lens may show no depth at all. To suggest that the depth of definition is equal in the two cases, as many would have us believe, is to my mind absurd. The measurement of the 'focal volume', that is the area of a diametrical section cut through the solid figure that would fill the whole space within which the defining power of the lens does not fall below the adopted standard, is a useful method of comparison, but better still is the diagrammatic representation of this section. Of course the practical depth of definition depends upon the standard of defining power adopted, and this will vary according to various needs."

Elliptical Modular Functions of Square Rank. In the 27th Vol. of the American Journal of Mathematics, No. 1, is found a paper by Professor John A. Miller "*Concerning Certain Elliptic Modular Functions of Square Rank*".

Professor Miller writes so plainly and definitely in regard to the development of functions of the higher modern mathematics, that it is a pleasure to read his articles for the sake of the history in them, if all readers can not follow the analysis of the themes that has come into use in recent years.

It is in our plan to ask Professor Miller to write a series of articles for this magazine that will be a connecting link between the old classical method of study that includes Calculus, and the branches below it, with those of modern analysis including that wide range of functions that are properly called higher Arithmetic, higher Algebra, higher Trigonometry and the higher Calculus. Such work needs to be done when some professors in college see that bright students in the study of ordinary college mathematics know nothing about the methods or extent of the modern phases of mathematics, even on the historical side of the subject. Still more is this desirable when it is known that teachers in high positions are asking questions that are very elemental about the proper classification of its common branches. It is time that some one makes a survey of the whole field of mathematics, ancient and modern, and coördinates its leading branches and properly relates them on a sound philosophical basis.

Total Eclipse of the Moon Feb. 8, 1906. The total eclipse of the Moon, Feb. 8, 1906, was observed and some of its phases photographed at Goodsell Observatory, Northfield, Minnesota. The night was perfectly clear, temperature about 0, and no wind.

The circumstances of the eclipse were closely fulfilled as predicted in the Nautical Almanac when reduced to Northfield time. The first contact with the shadow was marked at $11^h\ 55^m$, a little earlier than expected As the dark, circular shadow crept inward on the lunar surface from the east limb, it reached Kepler at $12^h\ 5^m$, it was on the bank of Mare Humorum at $12^h\ 11^m$, it was in the middle of Imbrium and entering Nubium at $12^h, 16^m$. In the 5-inch telescope the pinkish hue began to appear in the east limb. At that time details in the shaded part of the lunar surface were seen with the naked eye. Irradiation was also impressively strong. At $12^h\ 21^m$, the shadow passed Plato, and at $12^h\ 24^m$ it enveloped the north end of the Apennines. It quitted Mare Nubium at $12^h\ 30^m$ and struck Tycho at $12^h\ 32^m$. At an earlier time it looked as if the slightly curved shadow would exactly parallel the white broad streak from Tycho that cuts the sea of Serenitatis into two equal parts north and south, but it did not; it enveloped the south end at $12^h\ 34^m$; it reached Mare Cresium at $12^h\ 48^m$ and totality was complete one minute late by the Ephemeris, or $12^h\ 59^m$.

The change of color of the totally eclipsed Moon was a matter of considerable interest as it always is. The pinkish hue was strongly marked on some parts of the lunar surface during the entire period of totality. It was noticeable that when the total phase began, the eastern part of the disc was in a much paler hue than the rest of the surface. This lighter tinge of color gradually grew darker as the Moon went deeper into the shadow until when it was about central the color did not vary greatly on different parts of the disc except, as might be expected it would do on account of the different shades of color on the Moon's surface due to valleys and high plateau regions so easily seen by the naked eye. The elevated portions of the surface should appear in lighter hue, while the seas should look darker. As the eclipsed Moon began to approach the eastern limit of the Earth's shadow the eastern limb of the Moon began

to brighten and the western part looked darker, exactly reversing the conditions that were seen in the first half of totality.

It is easy to understand why the Moon takes on the copper color during the period of totality. Elementary text-books on astronomy explain the cause of this color as due to the refraction of sunlight through the Earth's atmosphere, those rays which pass through considerable depths of it are sufficiently refracted to reach the Moon in all parts of her path while passing through the Earth's shadow. For those rays of sunlight that thus go through the lower strata of the Earth's atmosphere, there is about 68 minutes of arc of refraction on the average at the distance of the Moon. Since the Moon is about thirty-one minutes in diameter, the refracted sunlight from one side of the Earth would cover a space in the Earth's shadow of more than twice the diameter, of the Moon. If in any particular eclipse the Moon's apparent angular diameter was thirty-one minutes and the Earth's shadow was two and two-thirds the diameter of the Moon then the Moon's path centrally through the shadow would be nearly eighty-three minutes of arc long during the period of totality. Since the refraction from any place on one side of the Earth would cause the copper-colored rays to cover sixty-eight minutes of the eighty-three, there must be fifteen minutes on the opposite side of the shadow which would not be covered by the refracted rays from that particular portion of the Earth's atmosphere. For the same reason light from all parts of the circle of sunset and sunrise atmosphere around the Earth would cause an outer ring in the Earth's shadow that ought to be less deeply tinted in color than those parts of the shadow that lie nearer the center. If the circle of the Earth's atmosphere that causes the refraction for the color of the Moon should be, throughout its entire circumference, uniformly clear from clouds and storms, during totality, there should be a gradual increase of color tint from the outer part of the shadow towards its center. If, however, some part of this atmosphere should be cloud-laden, there might be, on the lunar surface, at any time during the total phase, a variation of hue that could be easily seen by the naked eye.

In this particular eclipse the Moon's path through the Earth's shadow was not quite central; but, at the middle point, it was about seven minutes of arc south of the center of the shadow, making the time of totality a little less than it would have been if the path had been central. This shortened path would not of itself change the conditions on which the coloring of the lunar surface depend during the total phase. It was quite bright during the period, though somewhat darker during the middle portion than near the beginning and end. The interesting fact that is certain was that the color on the lunar disc was not uniform at any time during totality. For about twenty minutes after the total phase began the western limb was brighter than the rest of the surface. So, also, for about the same time preceding the end of totality the east limb became increasingly bright. In the midst of the total phase, the contrasts of color in different parts of the Moon's surface were distinctly considerable. This was not due, wholly to the difference in color of the seas and plateaus, although this fact was apparent and noticeable, as any one might expect, but the variation of hue must have been due to some outside cause and not wholly due to the effect of contrast, for that fact would not account for the way in which the patches of deeper tint shifted about on the disc. It is more probable that the real cause is in the condition of the Earth's atmosphere as already indicated. This total eclipse was strongly in contrast with the one in 1884, which was so obscured when near the center of the shadow that it could scarcely be seen with the telescope.

It was about as bright as the eclipse in 1895, which was photographed by Pro-

fessor Barnard with an exposure long enough to show the neighboring stars with distinct trails on the photographic plate.

At Goodsell Observatory Dr. Wilson took five photographs of the eclipse; one after the Moon entered the penumbra of the shadow, so far that nearly its whole width was seen on the plate, covering from one-fourth to one-third of the lunar disc; another after the shadow had cut off about 60° of the lunar circumference and blotted it out so thoroughly that it can scarcely be traced though the negative was developed unusually far. The last picture was made by the small camera attached to the photographic telescope. The plate was exposed 5^m, a few minutes after the Moon passed the center of the eclipse. The brighter stars show trails, the details of the lunar surface are seen and the unequal color shading is marked very plainly. It is a record somewhat like that made by Professor Barnard in September 1895.

Astronomy in the Old Testament.* By G. Schiaparelli. Authorized English translation, with many corrections and additions by the author. Crown 8vo. Oxford, at the Clarendon Press: 1905. Pp. viii., 178. 3s. 6d. net.

This is a translation of Professor Schiaparelli's Italian work, published some two years ago, thus rendering it available for English readers. It will probably come as a surprise to many to find how much can be written upon the astronomy in the Old Testament, and we must congratulate Professor Schiaparelli on the skill and clearness with which he has dealt with a difficult and involved subject. The author has brought to bear very much Hebrew and Assyriological learning, indeed, astronomers may, with some justice, complain that he has treated rather lightly the evidences of astronomy—a science that more than any other lends itself to exact investigation—as compared with the researches of the school of the German Assyriologists, of whom he himself writes in his preface: "When we consider, further, the freedom with which the writers of this school use their own imagination as instruments of research—and the ease with which they construct vast edifices of conjecture on narrow and shifting foundations—no one can be surprised that those ingenious and subtle speculations are very far from having obtained the unanimous agreement of the men who are capable of forming an independent judgment on these difficult subjects."

For instance, Professor Schiaparelli says, "In the present state of our knowledge, no one is in a position to prove that the zodiac and its twelve signs were already known at the time when Josiah exterminated the worship of the *mazzaloth* at Jerusalem (621 B. C.), "and in a footnote he proceeds further:—"A true Babylonian zodiac earlier than the Greek (that is to say, a series of twelve constellations arranged along the annual course of the Sun) has not, so far as I am aware, been yet published. The question of the origin of the zodiac is just now being valiantly debated by many learned men, and it would be presumptuous to express an opinion at this moment which did not rest on an accurate study of documents." Certainly "Assyriologists" are confused and inconsistent in their interpretation of the fragmentary constellational monuments which have been unearthed, but such documentary evidence is irrelevant to the point of issue. The old constellations themselves—of which the zodiac forms a coherent part—afford internal and *astronomical* evidence that they are of neither Babylonian

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* *Journal of British Astronomical Association*, XVI, 3.

nor Assyrian origin, but from a more northern latitude; and that they are of date much anterior—by millenniums—to the Greek tradition of them; of an origin, indeed, much earlier than the date assigned to the oldest of the books of Holy Scripture, even by the least advanced of biblical critics. And surely it is not presumptuous for an *astronomer* to consider, or even to attribute the greatest weight to *astronomical* evidence. The ignoring of all this astronomical evidence of the date and place of origin of the constellations, and of their coherency, has led Professor Schiaparelli to assume that the Jewish writers could recognize only such constellations as were suggested by the dispositions of the stars included in them. This assumption, unhappily, vitiates many of his arguments.

Professor Schiaparelli argues strongly that the Hebrew words *mazzaloth* and *mazzaroth* should be taken as referring to the planet Venus. He bases his argument chiefly on the reference in 2 Kings xxiii., 5, to those who burnt incense "to the Sun, to the Moon, to *mazzaloth*, and to all the host of heaven, which he connects with the triad of stars which is depicted so frequently on Babylonian monuments. He says:—As a matter of fact, the Sun, the Moon, and Venus occupied a pre-eminent position in the Pantheon of the nations of Mesopotamia. In many and many a sculpture exhumed from the excavations made in Assyria and in Babylonia, and especially where any idea connected with religion appears, a triad of stars is found designed (symbolizing, no doubt, the corresponding deities), each of which has its own peculiar shape, identically repeated everywhere with the same type. These stars are the Sun, the Moon, and Venus." Certainly in later Babylonian times the symbols he depicts were associated with Sin, Simas, and Istar, and the two stellar designs were differentiated in shape, but this was merely a late and ignorant association. The triad itself is on a monument of a date when we have no reason or evidence for supposing that the planets were worshipped, or even recognized and at this date the two stellar symbols were *not* differentiated in shape, but exactly resembled each other. This is what we see on the triumphal stele of Naram Sin, whose reputed date is nearly 4,000 years before our era (if any credence whatever is to be given to the testimony of Nabonidus), and there is good reason for accepting the triad to represent merely a picture of the evening sky at the beginning of the first month of the year some 6,000 years ago, when the new spring Moon set parallel with the stars Castor and Pollux. It thus became a traditional symbol of the new year, even long after precession had dissociated the spring new Moon, lying on its back, from the twin star.

Professor Schiaparelli points out that the astronomy of Holy Scripture was remarkably free from all astrological taint; all reference to astrology—to the monthly prognosticators"—being but for the purpose of contempt. He also draws attention to a fact that is generally overlooked, that the astrological order of the names of the days of the week shows a late origin, and also proves that they are not a product of Babylonian astrology. The Babylonians divided their *nychthemeron* into 12 *kasbu*, but the order of the names of the week in astrology depends on the division of the *nychthemeron* into 24 parts. The order is also closely connected with the order of the seven planetary spheres adopted by Ptolemy, which does not go back much beyond the first or second century B. C, and whose order runs:—Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon. This argument ought to have some effect on those honest astrologers who base their acceptance of the cult on its co-origin and intimate connection with astronomy; but we fear it will not.

Polarization Observations of the Solar Eclipse August 30, 1905. A very interesting series of polariscope determinations are reported by M. Salet, who was appointed by the Paris Bureau of Longitudes to observe the recent solar eclipse at Robertville in Algeria.

His first effort was to detect any existence of a magnetic field in the neighborhood of the Sun, by observing if the plane of polarization of the coronal light suffered any deviations. This plane should, from reasons of symmetry, be radial if no magnetic field existed in the gaseous atmosphere. For these observations an equatorial telescope of 95 mm. aperture was employed, furnished with cross wires and a Savart polariscope placed before the eyepiece. This can be turned, before the observation, so as to suppress the bands due to terrestrial polarization. During totality the bands were well seen on the corona. The plane was found to be deviated in the right hand direction by 2° S. The smallness of this indicates that the Sun, in spite of its mass has only a slight magnetic field.

With another apparatus, M. Salet was able to obtain good photographs also of the coronal polarization showing fifteen bands on the width of the solar diameter. They are visible from about a diameter and a half from the solar limb, practically up to the edge of the external corona. The polarization had a maximum intensity about 5′ or 6′ from the Sun's limb, the plane of polarization being almost radial, and the slight deviation measured visually was thus verified. A prominence found crossing two bands apparently suffered no change of intensity, showing without a doubt the non-polarization of the prominence light. On none of the plates is there any trace of atmospheric polarization outside the corona or on the Moon.

For comparison several observations were made of atmospheric polarization by means of two Savarts directed 90° from the Sun, but at this distance no bands were visible during totality. At 30° or 40° from the Sun, however, the bands were easily seen during totality. In the neighborhood of the Sun, the plane of polarization was vertical.

A spectroscope was also provided with half its slit covered by a nicol. The spectra obtained show different intensities on the two halves by reason that on one the reflected solar light is suppressed by the nicol. The coronal radiation, strong up to 4′ from the limb is shown on both sides. Rays of hydrogen and calcium are also shown, and others which will be measured later.

From November *Knowledge*.

Essentials of Algebra is a new book for secondary schools which is an adequate preparation for entrance to college and for technical schools. Its authors are John C. Stone of the Michigan State Normal School and John F. Mills, Shortbridge High School, Indianapolis, Indiana. It consists of 412 pages besides appendix and index. The publishers are Benj. H. Sanborn & Co. of Boston, New York and Chicago.

This new book is well named, and its contents will cover the plan of a good and thorough preparation in the secondary school for advanced study in higher courses in mathematics.

The main thoughts worked out in this plan are extension of the idea of number, checks on mathematical work, factoring, the equation, correlation with science, expression of laws by equations, the graph, its meaning and uses.

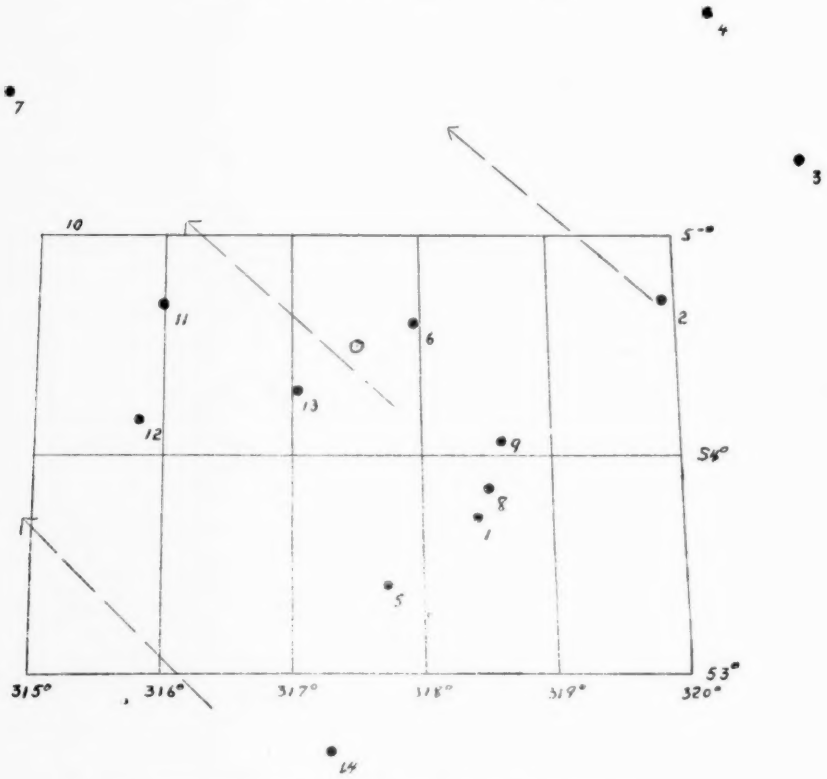
The authors have done a strong piece of work in this new book. It will doubtless be widely used.

Position of the Axis of Mars.—In Bulletin No. 24 from Lowell Observatory, will be found a complete study of the position of the axis of the planet Mars. The following diagram will explain itself.

NUMBER ON CHART.

1. 1877-1879, Schiaparelli from measures on South Polar Cap.
2. 1882-1884, Schiaparelli from measures on North Polar Cap.
3. 1882-1886, Schiaparelli from measures on North Polar Cap.

POSITION OF THE POLE OF MARS



4. 1884-1886, Schiaparelli from measures on North Polar Cap.
5. 1884-1886, Lohse from measures on North Polar Cap.
6. 1884-1888, Lohse from measures on North Polar Cap.
7. 1886-1888, Lohse from measures on North Polar Cap.
8. 1892-1894, Lohse from measures on South Polar Cap.
9. 1896-1898, Cerulli from measures on South Polar Cap.
10. 1901-1903, Lowell from measures on North Polar Cap.
11. 1903, Lowell from measures on North Polar Cap.

12. 1901-1905, Lowell from measures on North Polar Cap.
13. 1903-1905, Lowell from measures on North Polar Cap.
14. Struve from measures on Satellites.

⊙ The mean adopted for the position of the axis.

The arrows indicate the direction of the pole of the Martian Ecliptic.

From these determinations the probable value, as Mr. Lowell makes it, puts the pole of the axis in

Right Ascension 317.5 degrees.
Declination 54.5 degrees.

The tilt of the Martian Equator to the Martian Ecliptic is 23° 59′.

Comet *a* 1906.—Just as we go to press the following elements, ephemeris and observation notes of Comet *a* 1906, are received from Professor Herbert R. Morgan, which we are glad to include, though too late to be placed in their proper department of Comet and Asteroid Notes. For diagram refer to that drawn by Dr. Herbert C. Wilson, on page 171.

Elements and Ephemeris of Comet *a* 1906.—The following provisional elements were derived from three observations made at Glasgow on Jan. 27, 30 and Feb. 2.

T = 1905 Dec. 21.986600 Gr. M. T.
π = 15° 47′ 1.″ }
Ω = 286 17 53.″ } 1906.0
i = 126 29 0. }
q = 1.29468

Residuals (O − C)

Jan. 30. $\cos\beta\Delta\lambda = +3''.2$, $\Delta\beta = -0.4$
Feb. 8 $\cos\beta\Delta\lambda = -44.5$, $\Delta\beta = -18.4$

These agree very closely with a set derived from similar intervals by Miss Lamson, but the residual for February 8, did not pass, so a second solution from the observations of January 27, February 2, and one taken February 8, during the total eclipse of the Moon, gave the following set, from which the ephemeris is computed, and which agree with those of Drs. Crawford and Champreux.

ELEMENTS:

T = 1905 Dec. 22.330855 Gr. M. T.
π = 16° 20′ 1″.5 }
Ω = 286 25 14 .3 } 1906.0
i = 126 25 45 .0 }
q = 1.296509

Residuals (O—C): $\cos\beta\Delta\lambda = +2''.1$, $\Delta\beta = +0.9$

CONSTANTS TO EQUATOR (1906.0).

$x = r\,[9.803386]\sin(243° 31′ 7″.0 + v)$
$y = r\,[9.999833]\sin(331 35 37 .2 + v)$
$z = r\,[9.887770]\sin(60 17 20 .7 + v)$

EPHEMERIS.

1906 Gr. M. T.	True α (h m s)	True δ (° ′ ″)	Log.Δ	Br.
Feb. 24.5	6 17 1.1	+74 34 5	0.0088	0.78
28.5	5 55 46.4	68 9 30	0.0376	
Mar. 4.5	5 46 38.9	62 28 11	0.0693	
8.5	5 42 27.2	57 31 48	0.1022	0.45
12.5	5 40 43.8	53 16 25	0.1351	
16.5	5 40 26.1	49 36 36	0.1674	
20.5	5 41 2.8	46 26 57	0.1986	0.25
24.5	5 42 16.2	43 42 35	0.2284	
28.5	5 43 55.9	41 19 19	0.2567	
Apr. 1.5	5 45 54.8	+39 13 46	0.2835	0.15

Brightness January 27, 1906 = 1.10

The Observation of Comet *a* February 8, is

	Gl. M. T.	No. Comp.	Comet − ✳ Δα	Δδ
Feb. 8	13h 51m 2s	18, 7	+2m 54.″98	+1′ 6.″0

	Comet's apparent				Log p Δ	
	α		δ		α	δ
15ʰ	47ᵐ	47ˢ.21	+71°	28′ 21″.3	0.133_n	9.575_n

The star was found in the Greenwich Astrographic Cat. 1900, but afterwards the A. G. position was kindly sent me from Washington, by Miss Lamson, as most of my star positions are, causing a delay of a week. The mean place for 1906.0 is:

	α		δ		Red. to App. Place		Authority
15ʰ	44ᵐ	53ˢ.48	+71°	27′ 28″.3	−1ˢ.33	−13″.5	Gr. Astgp. Cat
		53 .64		29 .3			Dorpat A. G. Zones.

HERBERT R. MORGAN.

Morrison Observatory, February 20.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the first of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

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Astronomical News.—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time.

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

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Back volumes or single numbers are still on sale at the old prices, $2.50 and 30 cents, respectively.

WM. W. PAYNE,
Northfield, Minn., U. S. A.